A STUDY OF THE ANIMAL ECOLOGY OF AN ILLINOIS ELM-MAPLE FOREST

By

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I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY Asa Orrin Weese

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BE ACCEPTED AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE OF Doctor of Philosophy

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A STUDY OF THE ANIMAL ECOLOGY OF AN ILLINOIS ELM-MAPLE FOREST

A. O. Weese

I INTRODUCTION

1. Description of the Area Studied.- The area chosen for the present study is a tract of woodland some sixty acres in extent, located in Section 1 of Urbana Township, Champaign County, Illinois, about 4 1/2 miles east and 1 1/4 miles north of the main campus of the University of Illinois, and known as "University Woods". It is officially designated as the botanical, zoological and entomological reserve of the University of Illinois. The geographical location is, approximately, Latitude 40°8' North and Longitude 88°8'35" West. According to the Urbana Quadrangle map of the U.S. Geological Survey the 700-foot and 690-foot contour lines pass through the tract. There is little relief within these limits, and the drainage is poor, so that in wet seasons the soil becomes saturated with moisture, and water may stand for some time in the spring in depressions even in the higher parts of the woods. The soil is yellow-gray silt loam, an upland timber soil. (Hopkins, et al. 1918). McDougall (1922) has fully described the plant community of this forest. The higher parts are well wooded with a stand composed almost purely of maple (Acer saccharum) while a mixed stand of maple and elm (Ulmus americana) occupies the intermediate levels and elm is the dominant tree on the lower ground. Other prominent trees are, in order of abundance, according to McDougall, Fraxinus americana, F. quadrangulata, Tilia americana and Carpinus caroliniana. Many others, such as Aesculus glabra, Quercus rubra, etc., are present in smaller numbers, and in the more open situations there is a considerable growth of underbrush composed largely of Benzoin melissaefolium and Asimina triloba, with seedlings of the various species of trees comprising the forest. The forest floor herbage, during the summer season,

was dominated by Laportea canadensis except in the highest and lowest parts. Impatiens biflora and I. pallida were abundant where elms were the dominant trees.

The tract was for some time rather heavily pastured and some cutting of hardwoods (especially Juglans nigra) of which the stumps remain, had been done, but since its acquirement by the University of Illinois some five years previous to the present study, it has been left practically undisturbed as far as the direct action of man and of grazing animals is concerned. Accordingly reproduction of the woody plants is taking place to a considerable degree.

This small area is one of the very few remaining bits of the woodland which originally extended into the prairie of central Illinois along the Vermillion River and its tributaries, and like all other similar tracts it has been profoundly modified by the activities of civilized man. The first modification was, doubtless, the elimination of the larger mammals frequenting the deciduous forest under primitive conditions. The clearing for agricultural purposes of the greater part of the former wooded area limited the migration of species restricted to the dense woods, so that when a species lost its hold, for some reason, on a particular area, it was not replaced on the return of favorable conditions. It is probable that the period of heavy grazing drove from this particular area many forms which have been unable to return even though the conditions are now favorable for them, because of the isolation of the tract and the absence of suitable migration paths. No characteristic mammals, with the exception of the wood mouse (Peromyscus leucopus noveboracensis (Fischer)) are present in any number. Even squirrels of all kinds are rare.

At present, also, the value of the woods, particularly as an entomological reserve is being seriously impaired by the invasion of large flocks of poultry from the neighboring farm yards, which collect very industriously and very thoroughly such insects as are found in the leaf and upper soil strata. Environmental conditions are also profoundly altered, as far as these strata are concerned, by the drying out of the leaves and soil and the interference with the growth of the natural herbage occasioned by the activities of the fowls. Fortunately, not all of the tract is at present subject to this nuisance, as the invaders seem to find enough food without extending their depredations to the eastern portions.

The utilization of the neighboring lands for agriculture has led to the incurrence of many introduced forms, especially among those which may be classed as garden and orchard pests. Although, as will be seen above, the conditions studied here do not represent in any real sense the primitive conditions of the Illinois elm-maple forest, they represent the closest approximation available at the present time, and a much closer approximation than will be available in a few years if present processes are allowed to go on, unchecked.

Outline of the Topics Studied.- As indicated by the title, an attempt has been made to carry out an ecological study of the animals of this modified elm-maple forest. The study was undertaken with at least a partial appreciation of the limitations necessarily imposed by time and space as well as other more or less obvious difficulties. Thus the title is a broad one which is intended to cover the various phases of the subject treated, without any implication of completeness or finality. The work was begun during the

latter part of June, 1921, and continued for a period of nine months from that date, including the summer, autumn and winter seasons. It is intended that this paper shall be followed by a second, having for its main topic the vernal phenomena, thus completing the annual cycle.

As there could be no expectation of being able to cover the entire field suggested by the title, which would be in fact, a project calling for the efforts of several men over a considerable period of years, it was necessary that a choice be made as to the particular problems to be considered. This choice was, in part, made at the beginning of the work, and, in part dictated by expediency or the presence of opportunity as the work progressed.

It was, of course, obvious from the beginning that a first step should be the acquirement of data from a series of observations as to the physical conditions prevailing in the habitat under consideration, and a detailed examination of so much as possible of the climatic rhythm to which animals living there are subject. Such data must form the foundation of any adequate study of the ecological relations of the animals of a given habitat; in other words, we must know, as nearly as possible, what the habitat <u>is</u> before attempting to discuss the relations existing between it and its biota. It may seem that the records of meteorological observations occupy too prominent a place in this paper which purports to be zoological, but a large part of the subsequent work would have been worthless without a preliminary knowledge of the environmental factors involved.

Accordingly, first place is given to instrumental observations taking up in turn the succession and stratification of conditions of temperature, humidity, light, and the evaporating power of air.

Unfortunately, the observations on light could not be carried on continuously with the assistance of recording or cumulating instruments as could those on the other factors, and the data for but a single day are included.

Having made provision for obtaining a successional and stratal record of such environmental factors as could be measured with a degree of accuracy, an attempt was made at the same time and in the same place, to measure the biological components and, if possible, to correlate the results obtained from the two sources. The successional and stratal variations in the animal population were investigated and studied in relation to the environment. It may be emphasized here that collections of animals from the elm-maple forest, in the ordinary sense of the word, were not made. The data as to population depend on random sampling and not on general collecting.

As details in the study of seasonal and stratal succession some twenty-seven species present over a considerable period of time, or present in abundance over a shorter period, presented themselves for special examination. The problem of stratification also attracted further attention, and the definite stratal relations of certain of the spiders suggested the employment of these organisms in experiments involving gradients in environmental factors, especially those likely to play a part in producing the reactions resulting in stratification.

Another type of ecological study was undertaken in the attempt to determine the effect of environmental factors on the length of time spent by a spider in the cocoon during the winter, and early developments in this work brought to the attention the effect

of the factors studied on the time of emergence of a hymenopterous parasite infecting the eggs of the spider.

The methods employed and results obtained in the projects outlined above will be presented in the same order in the following pages, and the exposition of results will close with a brief resume and summary of conclusions.

A bibliography, together with an acknowledgment of the author's indebtedness to the many persons whose assistance has made this work possible will follow.

II METEOROLOGICAL OBSERVATIONS

1. Temperature.- Temperature data were obtained mainly by the use of recording thermographs. During the greater part of the period of study three such instruments were in use, although minor accidents at times prevented the proper functioning of one or the other for short periods of time, and one failed almost entirely during the winter period of low temperatures.

The sensitive element of the instrument recording soil temperatures was placed with its upper surface 10 cm. below the surface of the soil, which was, in turn, covered by the usual carpet of leaves and other debris, making, perhaps, in all, a layer 15 cm. in thickness above the thermometer bulb. Of the air temperature instruments, the sensitive element of one was exposed on the north side of an instrument shelter, within which the mechanical parts of the two instruments were housed. The bulb of this instrument was protected from the direct rays of the sun and from falling water, but was exposed to the free circulation of the air. The instrument shelter was located about 100 M. from the western edge of the forest

in a locality characterized by a mixed stand with elm and maple dominant, but not excluding other trees and shrubs. This shelter was in Quadrat No.76, according to the map in McDougall's (1922) paper. The shelter was so constructed as to expose the instruments at a height of about 60 cm. from the surface of the ground.

The third instrument was of the self-contained type, and was suspended by means of a rope and pulley about 10 M. above the surface of the ground, in a maple tree in McDougall's Quadrat No.54. In this case the sensitive capsule was protected from the sun's rays and from precipitation by the instrument case. The clock mechanism of this thermograph did not work well during the colder part of the year, and only partial readings were obtained after December 5, and figures obtained after this date are not included in the tabulations or graphs.

A standard Weather Bureau type maximum and minimum thermometer set was also installed in the instrument shelter, with the bulbs exposed approximately as in the case of the recording instrument. This was used in checking the thermographs. The thermograph in the tree could, of course, be checked with the mercury thermometers only when brought to the ground, which was done each week in order to change the record sheets. The other instrument, in the shelter, could be checked by means of the absolute maxima and minima as well.

The weekly record sheets were changed, in all cases, on Monday morning. In order to make the data obtained from the thermographs available for use, it was necessary to use some method of converting the linear records into figures. While, perhaps, many methods might have been used with equal success, the following practice was followed.

As the record sheets were ruled off into two-hour intervals, this period was taken as the unit. The mean temperature for each two-hour period was estimated and this mean recorded on the corresponding portion of the record sheet. The average of these means was then computed as the weekly mean temperature (Monday to Monday). The daily maxima and minima were also averaged, the indices of variation being the mean daily rise of temperature above the preceding minimum and above the preceding base mean. By this latter term is meant the mean temperature between the hours of 8 P.M. and 6 A.M. This period was taken because of the fact that in a typical twenty-four hours it is a period of relatively uniform temperature, or at least the period of most uniform temperature of the day. By 8 P.M. the evening rapid fall of temperature has ordinarily been completed and, although the temperature may continue to fall until 4 A.M. or 5 A.M., the fall is a gradual one, and the morning rise begins soon after 6 A.M. On account of the slight variability and the lag of the maxima and minima the base mean was not determined for the soil temperatures. Centigrade record sheets could not be obtained for some of the thermographs, so all temperatures were first recorded and all calculations made in terms of Fahrenheit degrees. The transposition to the Centigrade notation was made afterward.

The summaries of the air temperature data at 60 cm. and at 10 M. are given in Tables I and II, and the mean temperatures and mean variations are illustrated graphically in Plates I and II. It will be observed that the highest temperatures occurred during the first weeks of the period of observation, and that there was a gradual decline until the week of January 30. Marked variations from the general downward trend were noted during the weeks of

September 5, October 31, November 21, and January 9. After January 30 the trend was again upward. The most rapid declines in temperature were between October 31 and November 14 and between January 9 and January 23. The variation, from week to week, of the mean range was almost as great as that of the mean temperature. The excessive temperatures of the first weeks were accompanied by high variability but thereafter, until the end of October, the higher temperatures were accompanied by a smaller range. Again during the winter high temperatures were associated with a great mean daily range. In other words, the high means of mid-summer were occasioned by high maximum day temperatures, rather than by great elevation of nocturnal temperature, and the high means of late summer and early autumn are occasioned by a lack of the usual low nightly minimum. The chief factor in producing a low mean in the winter, again, is the absence of a high mid-day rise. The relations existing between the maxima and the "base mean" as described above is, accordingly, of great importance.

The differences between the temperatures at 60 cm. and 10 M. are brought out clearly in the tables and the graphs. With a few exceptions the weekly mean temperatures at 10 M. were higher than those recorded near the ground. Exceptions to this rule were recorded for the entire month of October and a portion of November. Observations at the German forest meteorological stations show, for deciduous forests, a reversal of the ordinary forest temperature gradient coinciding with the fall of the leaves. Thus, during the leafless season, the forest agrees with the open country in exhibiting a decrease of temperature upward. If the observations at the higher level had been continued throughout the winter it is

probable that this reversal would have become more apparent. The mean difference in temperature at the two stations during the period of complete records at both levels was 0.36°C., which would correspond to a difference of 1.94°F. per hundred feet, or approximately the figures (2°F.) obtained by the German investigators, according to Harrington (1893).

The data of Lorenz-Liburnau (1890) show an average difference of temperature between ground level and 11 M. in beech woods, according to numerous scattered observations, as follows

Time	Temperature at 0.0 M. Minus Temperature at 11 M.
Early morning (2:55-6:25 A.M.)	-0.1°C
Forenoon (6:15-11:00 A.M.)	+0.35°
Mid-day (11:00 A.M.-3:00 P.M.)	1.07°
Late afternoon (3:00-6:40 P.M.)	1.09°
Evening (5:50-9:55 P.M.)	0.44°

These observations covered the period between May 23 and October 28, near Vienna. While it was not practicable to calculate from the thermograph records the differences for the various hours of the day throughout the period of observation, this was done for what was considered a week of average days without any disturbing influences in the form of storms, high winds, etc., the week ending September 12. The temperature charts for the two stations for this week are reproduced as Plate III. It will be noted immediately that temperature variations at the two levels are closely related, and that the maxima of the higher station are somewhat higher, and the minima somewhat lower. A compilation of the numerical data for each two-hour period of the day, as obtained from these charts

gives the following results:

Time	Mean Temp. at 10.0 M.	Mean Temp. at 0.6 M.	Difference
6-8 A.M.	16.28°C	16.11°C	0.17°C
8-10	19.39	18.17	1.22
10-12 M.	22.06	20.78	1.28
12-2 P.M.	23.33	22.00	1.33
2-4	23.11	22.17	0.94
4-6	21.89	21.67	0.22
6-8	20.61	20.00	0.61
8-10	18.72	19.11	-0.39
10-12 N	18.11	17.94	0.17
12-2 A.M.	17.17	17.44	-0.27
2-4	16.44	16.61	-0.17
4-6	15.39	16.33	-0.94
		Average Difference	0.34°C

This is illustrated graphically in Plate IV. The average difference for this typical week is of the same order of magnitude as the average for the period of complete records as previously given. The variations in the vertical temperature gradient during the nycthemeral cycle also seem analagous to its variations during the annual cycle, in that a reversal takes place during the cooler periods in each case.

As the temperature at the higher station is greater during the warmer hours, and lower during the early morning, it follows that the mean variability of temperature is greater at this level. This is true during the summer and early autumn months, as will be

seen by inspection of Tables I and II and Plate II. During the latter part of the season the mean variability is less at the higher level, due, probably, to the greater effect of the sun on the temperature near the ground after the disappearance of the protective leaf-canopy.

Soil temperature is, of course, much more uniform than air temperature, and that within the forest, according to numerous observers, is much more uniform than that in the open at an equal depth. This is due, of course, largely to the lack of insolation and to the protective blanket of leaves and other ground litter. During the months when the deciduous trees were in leaf the maxima came at about 4 P.M. and the minima about 8 A.M., although sometimes delayed until 10 A.M. The variations became greater as the leaves fell, then decreased again as the ground froze, remaining very slight throughout the winter. A sudden rise, accompanied by daily variations of as much as 4°C. occurred during the week of March 13. This represented the temperature changes accompanying the thawing of the soil moisture during a series of early spring rains.

Soil temperature data are given in Table III and illustrated in Plates I and II. Although the mean soil temperature showed variations in the main closely correlated with those of the air near the surface of the soil, this mean, during the summer, was about 5° below the air mean. Beginning with the week of November 14, a lag became apparent and the magnitude of the changes from week to week became decidedly less in the soil. During this period the mean temperature of the soil averaged higher than that of the air, thus reversing the condition found in the warmer season.

In summer the temperature increases from the soil upward to

the forest crown; in winter the highest mean temperatures are in the soil, and temperature decreases upward. In summer the temperature is most variable in the forest crown and least so in the soil; in winter the soil is still the most stable, but the greatest variation is now found in the air stratum just above the soil.

2. Humidity.- Humidity data were obtained by the use of recording hygrographs. Of these, one was an integral part of a combined hygrothermograph located in the instrument shelter already mentioned in connection with the discussion of the temperature data. The other instrument was suspended in the maple tree also previously mentioned, with the thermograph. The hygrographs were standardized each week by reference to humidity data obtained by the use of a sling psychrometer of the approved Weather Bureau type, and were also carefully compared after a short period at the same level. The data obtained were treated in substantially the same way as those obtained from the thermographs, and the results are similarly tabulated in Tables IV and V and illustrated in Plate V. In this case, however, the base mean has a high value because the period of comparative uniformity in relative humidity of the air is the period of the greatest percentage of saturation. This period falls between the same hours as those chosen to represent the temperature base mean. An additional column contains, for the 60 cm. station, data as to absolute humidity, expressed in millimeters of mercury partial pressure. The figures in this column were obtained by calculation from the mean relative humidity and the mean temperature for each week.

The relative humidity curve shows a very low point during the third week (week ending July 18) and two high points, during

the tenth (ending September 5) and twenty-second (ending November 28) weeks. The mean relative humidity for the whole period lies somewhere about midway between the high and low points. The absolute humidity curve rises and falls, in a general way, with the curve just mentioned, with a general downward trend due to falling temperature. There are several differences between the curves which can be explained by temperature variations. According to Lorenz-Liburnau (1890) relative and absolute humidity vary together in the same direction in the forest, on account of the fact that the forest is a source of water vapor, as well as of cooling. The present observations show this to be true in general, during the summer and autumn months, but not to any great degree during the winter.

Examination of the variation curves shows that, in general, a wide range accompanies a low mean relative humidity. This is because of the fact that the moisture content of the air rarely fails to reach saturation during the night hours, and a low mean relative humidity is almost always caused by a very low day-time value.

A comparison of the data from the station between the herb and shrub strata with those from the tree station shows an almost invariably greater mean relative humidity in the former situation and a greater mean daily range in the latter. There were three slight exceptions to the latter statement, and four cases in which there was no difference in mean relative humidity at the two stations. The average difference for the entire period of observation was 3.5%.

Lorenz-Liburnau's data show the following differences of relative humidity between the ground level and a height of 11 M., in beech woods:

Time	Relative Humidity at 0 M. Minus Relative Humidity at 11 M.
Forenoon (6:17-11:00 A.M.)	5.8%
Mid-day (11:00-3:00 P.M.)	10.9
Afternoon (3:00-6:18 P.M.)	8.0

The greatest differences were observed to be between the ground and a height of 5 M. Data obtained by the use of atmometers, as will be seen later, would place the zone of the most rapid decrease in humidity within a meter of the surface of the ground. Lorenz-Liburnau obtained, as an average of 79 observations between May 23 and October 16, a difference of 7.73% between the relative humidity at the soil surface and that at 11 M. His method, however, left entirely out of consideration the hours between 9 P.M. and 4:30 A.M.

The hygrograph records for the week ending September 12 were analyzed in the same way as the thermograph records for the same week, and the means for each two-hour period were obtained, with the following results:

Hours	Mean R.H. at 0.6 M.	Mean R.H. at 10 M.	Difference
6-8 A.M.	95.0%	95.0%	0.0%
8-10	90.0	84.3	5.7
10-12 M	77.1	76.0	1.1
12-2 P.M.	77.0	71.3	5.7
2-4	80.5	70.3	10.2
4-6	86.0	73.7	12.3
6-8	88.5	81.8	6.7
8-10	92.8	87.5	5.3
10-12 N	93.5	91.8	1.7
12-2 A.M.	93.7	92.0	1.7
2-4	94.0	93.0	1.0
4-6	94.8	95.3	-0.5

Average Difference 4.3%

See Plate IV for a graphic representation of the temperature and humidity variations during the "ideal day".

The low average difference as compared with that obtained by Lorenz-Liburnau may be explained by the fact that his observations left out of consideration those hours when the humidity differs least at the various levels, and the fact that the lower level used in the present observations is not at ground level but 60 cm. above.

Relative humidity of the air is greatest at ground level in the forest and decreases upward, very rapidly at first and then more slowly. During early morning hours or during fogs, rains, etc., there may be no gradient. The temperature relation is such that, even with the same amount of absolute humidity at the different levels, a gradient in this direction would be present. However, the gradient, especially near the ground is too abrupt to be caused by the slight temperature differences alone, and there is a gradient in absolute as well as relative humidity.

3. Light.- It was not possible, on account of lack of time and the unsuitability of apparatus at hand for continuous observation, to conduct extensive observations on the quality and quantity of light available for organisms at various levels of the woods, and at various times. However, a short series of readings was made with the Macbeth Illuminometer. These readings were taken in the period between noon of August 29 and noon of August 30, while supplementary readings were taken on July 30 and August 22. Both of the days last mentioned, however, were unfavorable for comparative observations on account of partial cloudiness. On August 29 and on the day following, until about noon, the sky was clear, although somewhat hazy, and clouds did not begin to interfere with the

readings until after noon.

Observations were taken at the ground level, under the shelter of a leaf mosaic and at the height of 1.35 M. in a group of tall maples with fairly dense foliage, and in a sunny glade at the western edge of the woods. The test plate was horizontal in position in every case, and an amber colored filter with a transmission factor of 1.9 was used to equalize the color values of the standard lamp and daylight. In most readings absorption screens of neutral color were used to bring the difference in brightness of the two fields within the range of comparison of the instrument. The use of such screens is indicated in each case by the inclusion of the screen factor in the table opposite the reading. The data obtained are tabulated in Tables VI, VII and VIII, and illustrated graphically in Plates VI and VII.

Additional readings were taken at each station with the use of color screens, but as it has been impossible to obtain a spectrophotometric analysis of these screens in comparison with a similar analysis of the light emitted by the standard lamp, the data thus obtained are omitted here. The results indicated, however, a variation through the day in the relative constitution of the light as well as a difference in the quality of the light at different levels in the forest and in the open glade. As observations could not be taken at any two places at exactly the same time, any evidence based upon small differences must remain inconclusive.

As to intensity of light the results were, of course, much more definite and conclusive. The light at 1.35 M. but once during the day reached one percent of the intensity of full noon sunlight,

and the highest percentage reached at the ground level, under the cover of herbage, was 0.35% of full sunlight. Both of the forest readings were, of course, taken in shade. Throughout the day, flecks and small patches of sunlight find their way through the leafy canopy. Their intensity is difficult to measure, but the smaller flecks probably approximate one-half of full sunlight intensity, and larger areas have their intensity but little diminished. Be that as it may, the difference between light at the lower levels in the forest and that at corresponding levels outside is very large, and the ratio of light intensity between the ground stratum and the shrub stratum may be as high as one to three or four. This factor has been little considered in connection with the study of the distribution of animals, but it deserves thorough consideration now that instruments for its measurement are being developed.

4. Evaporating Power of Air.- The use of the evaporating power of the air, determined by the porous cup atmometer, as a summation of the effects of temperature, humidity, air movement, insolation, etc., has been too well established by various investigators to require discussion here. During the season favorable for the use of the porous cup atmometer, i.e., during the season without temperatures below the freezing point of water, these instruments were exposed in twelve different places in and at the borders of the woods. Although observations at all of the stations were not begun on the same date, and although there were some interruptions due to accident, a fairly representative series of readings was obtained.

The atmometers were mostly new and had been standardized by the manufacturers. A few which had been used had been standardized

since their use by the Illinois Natural History Survey. All were again standardized at the end of the period of exposure, and in some cases, standardizations were made at more frequent intervals. The weekly readings were then reduced to those of a standard atmometer for purposes of comparison.

The cups were all mounted on bottles fitted with two-hole rubber stoppers, and supplied with a filling tube. Each week they were filled, from a burette, to a mark on the filling tube, which was covered at other times by a loosely fitting glass cap. The instruments suspended in trees were protected by a cylindrical guard of coarse wire netting. No rain correcting device was used, but this fact does not seem to have introduced discrepancies into the data.

Atmometers were exposed at the following stations:

1- On the top of the instrument shelter 1 M. above the surface of the ground, surrounded by large elm and maple trees and by lower trees and shrubs, such as ironwood, white ash, buck-eye, red oak, spice-bush, red-bud, etc.

2- About 3 M. from the instrument shelter, on the ground, under cover of a thicket of Benzoin. The porous cup was about 10 cm. above the surface of the ground.

3- At a height of 1.5 M. on the south side of the trunk of an ash tree, 25 cm. in diameter, about 1 M. from the instrument shelter.

4- At the same height, on the north side of the same tree trunk.

5- At a height of 2.5 M., suspended under a leafy branch of a small hard maple, about 3 M. from the instrument shelter.

6- In a hollow stump about 20 M. from the instrument shelter. The heart of the stump was decayed so that the cavity reached down

almost to ground level. The cortex was also broken away on the southeast side, leaving an opening about 30 cm. in width.

7- At the west edge of the woods in the short grass near the roadside. This atmometer was stolen during the week ending August 1, and observations at this station were discontinued.

8- At a height of 6 M. in an elm tree about 10 M. from the instrument shelter.

9- At a height of 10 M. in a maple tree about 50 M. from the instrument shelter in a group of large maple and elm trees.

10- This instrument was first exposed at a height of 12 M. at the top of the same tree as No.8. After September 12 it was removed to the top of a buck-eye midway between the instrument shelter and Station 9.

11- At the east edge of the woods, in tall grass. This station was selected after the interference with the atmometer at Station 7.

Table IX gives the data obtained from this series of observations. Plates VIII, IX and X illustrate graphically the relations between the amounts of evaporation at the different stations. The relation between evaporation (at Station 1) and rainfall (at Urbana) is also shown by Plate XI.

Beginning at a rather high level during the first week of observation, evaporation reached a maximum during the week ending July 18. This was followed by a rapid fall and a minimum during the week ending September 5. From this point there was a gradual rise until October 24, when a second maximum occurred. The first maximum was clearly due to high temperature coupled with a lack of rainfall, while the minimum following was due to a heavy rainfall, without, however, much diminution of temperature. The second

maximum was due to a lack of rainfall and to the greater circulation of the air and insolation due to the falling of the leaves. Severe frosts had occurred during the week ending October 10, and it was feared that the atmometers would be destroyed if left out longer. The instrument at Station 1 was left, however, until it was broken by freezing, during the week ending November 14.

Although there were a few minor exceptions, the data show a more or less constant gradient in the evaporating power of air, from the ground level upward. This is what would be expected in view of the gradients in humidity, temperature and light already discussed. Wind movement, also, probably increases upward, although no instrumental measurements of this factor were made.

Using the record of the atmometer at the instrument shelter as a basis for comparison, it will be seen that, although the difference between the evaporation here and half a meter higher on the trunk of the small tree (Station 3) was very small, there were only two weeks during the entire season when a difference was not recorded. The difference between the north and south sides of the tree was negligible until the last three weeks, when it was about 0.9 c.c. per day less on the north side. This difference was evidently due to the greater exposure to sunlight of the instrument on the southern side. The differences between the 1 M. level and the 1.5 M. level were greatest during the weeks of August 1, August 15, and September 5. These were weeks of comparatively great rainfall, and the lower air strata were evidently more thoroughly saturated with moisture, due to the greater amount of water in the soil.

The evaporation from atmometer Number 5, suspended from a maple branch 1.5 M. above Number 1, and 1 M. above the instruments

just discussed, followed that obtained from the latter very closely, falling below in one instance, the week of August 1. This was a week of heavy rainfall, as mentioned above, and under the dense cover of the maple branches the moisture laden stratum was thicker than under the less compactly foliaged trees. Also, during the last two weeks, the greater protection afforded by the maple branch caused the evaporation from this station to follow that of Station 1 rather than that of Stations 3 and 4.

The evaporation from atmometer Number 9, at 10 M. followed, in a general way, that at the stations previously discussed. It was, in almost every instance greater than at the other stations, the exceptions being the weeks of September 26 and October 10. These exceptions are slight, and can be explained by the fact that the gradient became less marked at this time on account of the fall of the leaves, and that slight variations in any direction might be expected due to the later fall of leaves from some trees than from others.

The evaporation from atmometer Number 8, at 6 M. above the surface of the ground fell between that from Numbers 5 and 9, as might be expected, except for the week of September 5, when it was almost as low as Number 1, and September 19, when it was higher than either. For the weeks of September 26 and October 3 it was practically the same as for Number 9. The rise in the last three weeks is probably explainable by the earlier fall of the leaves of the elm tree and the greater exposure to the west wind.

Atmometer Number 10, at the upper margin of the forest crown showed, naturally, the greatest evaporation of all. The drop in

the evaporation from this instrument and from Number 8 during the week of September 5 was partially due to the accumulation of air in the porous cups. The readings are given, however, as they were obtained.

Atmometer Number 2, near the ground varied almost exactly with Number 1, with an average difference of 3.2 c.c. per day.

The evaporation in the hollow stump (atmometer Number 6) followed that from atmometer Number 2, except, apparently, for the weeks ending July 11 and 18. This discrepancy was probably due to an error in filling the bottle on the former date. It was located in very poor light, and an error of that kind was easy to make.

The evaporation from the forest edge stations is not illustrated in plates VIII and IX. That at the west forest edge, in short grass, was very much higher than elsewhere, with the exception of the tree tops. At the east forest edge in long grass, the evaporation was about the same as at 6 M. in the woods.

Plate X gives the comparative evaporation at the various stations, computed as the average daily rate between July 1 and October 10. In the case of Stations 1 to 6 inclusive, the calculations were made directly. In the case of the others, where observations did not cover the entire period, the result was obtained by comparing the evaporations recorded with those recorded at Station 1 for the same dates, and assuming that the same relative ratios would hold for the entire season. The values thus obtained were as follows:

Station	1	2	3	4	5	6	7	8	9	10	11
Mean Wkly. Evap.c.c.	9.16	5.96	9.90	9.63	10.4	4.14	14.03	12.20	12.31	15.71	11.91

The gradient of the evaporating power of air in the forest is very striking, stations less than a meter apart, vertically, showing definite and constant differences. This is particularly true at the lower levels. At the higher levels the gradient still persists but is subject to irregularities due to the greater exposure and lack of uniform conditions. The steepest gradient, also, is near the ground. An organism passing from the air stratum just above the soil to the top of a tree would enter a region of three times the average evaporating power, and many more times the diurnal variation in evaporating power. Evaporating power is more than doubled in passing from the herb stratum to the upper shrub stratum. It is probable that conditions under fallen leaves and debris are somewhat approximated by those in the hollow stump. An animal traveling from the interior of such a hollow stump to its top would be subjected to double the evaporating power. Such considerations serve to point out the extreme importance of this environment factor and to emphasize the steepness of the gradient in that region of the forest in which stratification of animals is most complete.

III BIOLOGICAL OBSERVATIONS

1. The Animal Population as a Whole.- An attempt was made, throughout the period of study, to obtain collections, or rather samples, of the animal population as nearly equivalent as possible and in a manner at least roughly quantitative. All collections were made near the meteorological stations previously discussed, and collections from the different strata were generally made on the same day. There were exceptions to this rule, particularly in

the first part of the season. In a few instances, a week was allowed to pass without a sample being taken from one or more strata, but this was unusual, except during the coldest part of the winter, when few collections were made in the shrub stratum. In the tables and the text all collections are dated according to the last day of the week in which the collection was made, reckoning from Monday to Monday. This day was chosen for convenience because of the facts that the thermograph and hygrograph sheets were changed at this time, and that means of climatic factors could be computed most easily sheet by sheet.

Because of the unusual difficulties attendant upon quantitative collection from the tree strata, no systematic samples were taken from this level. The remaining strata considered were the Shrub, Herb, and Ground strata. Because of the constant presence in the forest of a blanket of leaves on the surface of the soil, the Ground stratum was divided, for the purpose of this study, into two parts, which will be referred to as the Leaf and Soil strata. Of the latter only the upper 10 cm. were considered.

The unit sample from the soil and leaf strata was taken from an area 2 ft. (0.61 M.) square. Leaves and other debris from this area were first gathered and placed in boxes made of fine wire screen, the contents of which were later sorted in the laboratory after the animals had been quieted by the use of ether. After the leaves had been removed the soil of the bared area was carefully gone over to a depth of 10 cm. and all animals obtained placed in vials for further assortment in the laboratory.

The unit sample from the herb and shrub strata was that obtained by ten short sweeps through the vegetation with an insect

net whose sub-circular opening averaged 30 cm. in diameter. The contents of the net, after sweeping, were transferred to screen cylinders or to paper bags, and taken to the laboratory for further examination, in the same manner as above described for the leaf samples.

It is not claimed that there is any exact correspondence in the numerical data as obtained from the different strata by these methods, although the ratios so obtained are probably in the right direction and of the right order of magnitude. The method of collection was probably most efficient with respect to the leaf stratum, the soil stratum and the herb and shrub stratum following in the order named. Assuming the average depth of the herb stratum to be 0.5 M. and the average length of the sweep of the net to be 1.0 M., it will be found by calculation that ten such sweeps include approximately the volume of vegetation above the unit area. The foliage of the shrub stratum may also be assumed to be of approximately the same depth, although the relative efficiency of the sampling method is less in this stratum.

The numerical data obtained from samples taken in the manner described above are given in Table X and the relations are illustrated graphically in Plates XII and XIII.

Examining first the curve representing the total population in all strata considered, we find a fall in the fourth week (the week of July 25) corresponding to an increase in the evaporating power of the air at this time. At the beginning of the period of study, the woods were rather dry, due to a protracted period of heat and drouth during June, and the animal population was already small. Sanders and Shelford (1922) found an increase of population

under conditions of drouth and high temperature in a pine-dune community. This suggests an important difference between the two communities. With the increase in moisture content of the air (and of the soil-leaf strata) during the following weeks, there was a marked increase in the size of the collections, and the great increase culminating in the high maximum during the fourteenth week (ending October 3) might seem to be largely due to this cause. A gradual decline in temperature had been going on, however, together with a considerable increase in mean variability due to lower temperatures at night, so that, while the initial increase was certainly due to a return to moisture conditions nearer to the optimum for the species concerned, the sudden and great increase in the number of organisms taken in the samples was due almost entirely to the great autumnal migration toward places of hibernation. An analysis of the samples taken at this time showed that the great maximum was caused almost entirely by a few genera of beetles and two genera of Cicadellidae, all hibernating species in course of migration from the forest margin to the leaf stratum of the more protected portion of the woods. Following this maximum, the fall was again rapid, as temperatures continued to fall (the first heavy frost was the night of October 4), which doubtless stimulated the insects in question to seek more complete shelter. The peaks in the totals curve after November 12, the date of the first ice formation, were caused by samples taken on warm days when insects partially emerged from hibernation, or at least, approached near enough to the surface of the soil or leaf strata to be collected.

The relative relations of the size of population in the various strata may be discussed with interest. The largest numbers,

during the summer months, were found in the leaf and herb strata, and, for the most part, the curves representing the populations of these two layers seem to vary together. Both showed marked minima during the excessively dry week of July 25, and both rose as the weather became more favorable. The leaf stratum as well as the herb stratum exhibited the marked maximum of October 3, due to the influx of hibernating insects. The low point in the leaf stratum curve for October 17 may be due to the chance selection of a poorly inhabited area. At any rate, after the fall in the herb stratum curve, there was a second maximum, due evidently to the downward migration of the insects which were, the week before, in the herb stratum. After this date, the decline of the herb stratum curve was very rapid, and the course of the totals curve was almost entirely governed by that of the leaf stratum. The large numbers found in certain of the late winter collections were partly due to the appearance of larvae of forms passing the winter in this state.

The shrub stratum showed, in general, variations in population paralleling those of the strata below. It is of interest, however, to note that the autumn maximum in this stratum came a week earlier than that of the herb stratum. The collection of this date, also, was the only one showing a larger population in the shrub than in the herb stratum. This relation was due to the fact that the insects of the forest margin first migrated inward at the level of their occurrence in that locality, later migrating downward for hibernation. This instance affecting the populations of the shrub and herb strata, and the instance mentioned previously for the herb and leaf strata are the only cases of evidence from numerical data alone of stratum to stratum migrations.

The most striking phenomenon of the entire period covered by the collections was this autumn hibernating reaction, evidenced by migration inward from the forest margin and downward to the forest floor. The principal inciting factors seem to be the fall in temperature and the great daily range of temperature of the early autumnal period. The fact that a large number of species react alike and at the same time to the same stimulus or combination of stimuli shows a large degree of similar adjustment to the climatic rhythm of the temperate savanna region on the part of characteristic insects of that region. This phenomenon will be discussed more fully in connection with the consideration of the records of the occurrence of individual species in the samples. Tables XXIV to XXXIV, inclusive, give details as to the specific make-up of the collections insofar as determinations have been made at this time. A few important groups, notably the Lepidoptera and the greater part of the Heteroptera remain unidentified at this date, due to delay in transit or unavoidable delay on the part of the specialists to whom they have been submitted.

2. Dominant Species.- Certain species which were present in the samples over a considerable period of time, or abundantly for a shorter period, were chosen for further study from the standpoint of seasonal succession. As the study did not begin in early spring, nothing of the character of a phenological analysis could be made, but it is felt that the data obtained may, nevertheless, be of some value.

The animals chosen were, for the most part, arthropods, -- spiders and beetles, because of the greater abundance and more conspicuous character of these groups. Hemiptera might have been

used in large numbers, but, aside from the Cicadellidae, and other less abundant families, the systematic identifications were not received in time for inclusion at present. Outside of the Arthropoda, the Mollusca furnished the only group sufficiently abundant to be of use in this phase of the study.

The data obtained as to seasonal succession and seasonal variations in abundance may best be illustrated by reference to Plates XIV to XXII. In Plates XIV to XVIII vertical distribution as well as time distribution is represented. The distribution of each species found in more than one stratum is indicated by a separate solid frequency polygon for each stratum, the base line for each stratum being separate. Time is represented as in Plate I and others, by vertical lines at five-week intervals and by less conspicuous divisions at one-week intervals. The vertical scale is always the same for the same species, but is not necessarily the same for different species.

Mollusca

Polygyra thyroides (Say) Plate XIV

This snail was found abundantly in the leaf stratum during the week ending July 11, and in smaller numbers thereafter. There were a few individuals in the herb stratum at this time, and with the approach of a period of relatively high humidity large numbers were evident in this stratum. The maximum number was found during the week ending August 8. Dryness again prevented the snails from ascending to this stratum for a time, but a second period of low evaporation allowed them to ascend even to the shrub stratum, where they were found in maximum numbers on September 11. This series of observations illustrates very clearly and definitely the relation

of these snails to moisture. Baker found thyroidesin a wide variety of habitats and it seems to be able to endure a considerable amount of dryness.

Circinaria concava (Say) Plate XIV

The normal habitat of this carnivorous species is in the leaf and soil strata, and it is found only occasionally on low vegetation, as was the case on August 8. The periods of maximum abundance, or rather, the periods when the greater numbers were taken, corresponded to periods of low evaporation. It should, perhaps, be mentioned that the first maximum shown by the frequency polygon was occasioned by animals found in the soil stratum, while the second maximum was due to snails from the leaf stratum. The latter were found during the period of greater humidity. The leaf stratum is, of course, more subject to drying than the soil stratum. A single hibernating individual was taken from the soil stratum January 9.

Vitrea indentata (Say) Plate XIV

The occurrence of this snail can not be explained on the basis of moisture, as is the case of the other two. The first maximum, on October 3, coincides with a period of high humidity, but the second, on October 31 and November 7, does not. These collections may, perhaps, be explained on the assumption that the sample included groups which had come together for hibernation. Single hibernating individuals were, however, taken at various times throughout the winter.

Insecta
Coleoptera

Notoxus monodon Fab. Plate XV

This beetle (Anthicidae) was first taken from the herb stratum August 29, the maximum at this level being reached during the week of October 3. It is a forest margin species hibernating in the forests, and its early appearance on forest herbage represents the first step in this migration. Very large numbers were found among leaves on the ground October 31, and during the entire winter, on warm days, especially, considerable numbers were taken from this stratum.

Telephanus velox Hald. Plate XVI

This beetle was found on herbage October 3, and thereafter throughout the entire winter in the leaf stratum. The maximum occurrence was on November 7.

Phalacrus politus Melsh. Plate XVI

Included in the chart in Plate XVI are other Phalacridae as well as Phalacrus politus, to which species most of the family taken belonged. They were among the most abundant beetles found after September 26, when they were observed in the samples from all three strata. The numbers from the shrub stratum were small, however, and none were taken from this level after October 31. The maximum in the herb stratum came October 3, and on this date, also, was the first maximum for this family in the leaf stratum. A second maximum appeared on November 7. The week ending November 7 was characterized by three fairly heavy frosts, and a marked general fall of temperature. The first maximum, on October 3, followed a period of falling temperature, and great variation between night and day, without, however, any actual freezing temperature, while the maximum in the leaf stratum followed a similar period with considerable lower temperatures. P. politus is a forest margin species

and its presence in the denser forest was an indication of a hibernation migration. The species was found all winter in hibernation in the leaf stratum.

Glyptina spiria Lec. Plate XVII

This Chrysomelid was found in the shrub stratum from September 5 to November 7, and after that date in the leaf stratum. A few individuals were also swept from the herb stratum on November 21, which was a comparatively warm and sunny day. The summer habitat of this species is the forest border and roadside, and its appearance in the forest collections is due to its hibernating reactions. Individuals were found throughout the winter, especially on warm days.

Epitrix brevis Schw. Plate XVII

Enormous numbers of E. brevis were swept from the herb stratum October 3, the first individuals being taken from this level on September 19, and the last, October 17. A few were swept from the shrub stratum during the week of September 26, and a few hibernating individuals were obtained January 16 and 23. The sudden appearance of this beetle represents a migration, en masse, in preparation for hibernation. The small numbers taken during the winter are due, evidently, to deep hibernation. Beetles of this size and color would also be difficult to distinguish in soil, so that perhaps some may have escaped notice.

Epitrix fuscula Crot. Plate XVII

While not found in as large numbers as the other member of the genus, this little beetle was fairly abundant after September 26. None were found elsewhere than in the leaf stratum where hibernation took place. It was found in much larger numbers through

the winter than E. brevis. This, also, is a forest margin species, feeding principally on plants of the family Solanaceae, near the roots of which the eggs are laid in the spring. According to Somes ( ) there are three broods per year in Missouri.

Chaetocnema confinis Crot. Plate XVIII

This forest border species was first taken from the shrub stratum September 19, becoming abundant on September 26. Thereafter the numbers appearing in the samples decreased gradually. One individual was taken from the leaf stratum November 14. It is probable that the species hibernates in such situations as not to be found ordinarily by the methods of collection used in the present instance. The sudden appearance of the insect indicates a forestward migration following temperature conditions characterising the approach of autumn.

Phyllotreta sinuata Steph. Plate XVIII

This species of the forest border and meadow was found in small numbers on July 18 in the leaf and soil strata, but the real migration did not begin until October 3, culminating in a maximum on October 17. Hibernating individuals were noted in the collections throughout the winter, the number observed increasing with the first warm days of the season. The principal migration of this beetle, apparently, took place only after several rather severe frosts.

Longitarsus melanurus Melsh. Plate XVIII

Although taken from the herb stratum only, the frequency polygon of this beetle is typically like those of other beetles coming to the forest for hibernation, and it is probable that hibernation took place in situations from which collections were not

made. This species is found during the summer in the rank herbage along roadsides and in other similar situations.

Chalepus nervosa Pans. Plate XV

Although present in the herb stratum throughout the summer this species became most abundant September 26. It was swept from the shrub stratum, also, on September 12. It seems to be a characteristic forest border species, and the principal larval food plant is said to be the dogwood. The adult is normally found on weeds and shrubs of many kinds, perhaps more especially on the goldenrod. Two generations occur, the first maturing in mid-summer, and the second in autumn. It was evidently this second, hibernating, generation which caused the maximum of September 26. Hibernating individuals were not found.

Diabrotica vittata Herbst. Plate XV

The striped cucumber beetle is a forest margin beetle which has become a pest by invasion of cultivated fields. Autumn finds many individuals in the forest in preparation for hibernation. The first large collection was from the leaf stratum on September 12. On sunny days, later it was swept from shrub and herb strata. Remains of dead beetles found during the winter indicated that the number completing hibernation is probably relatively small. Probably only those in the most protected situations are able to survive. Mating takes place in early spring on Crataegus and Prunus, typical forest margin trees.

Phytonomus nigrirostris Fab. Plate XVI

The lesser clover-leaf weevil seeks its hibernating quarters very early in the season. According to Mr. Faustino Otanes, who made systemmatic collections on alternate days from a clover field

on the experimental farm of the University of Illinois, very few were found there after July 7. They were found, in small numbers, in the woods in the herb and leaf strata from the beginning of the series of collections. None were swept from herbage after September 26. Maximum collections were made from the leaf stratum on September 12 and October 31. The former date followed a week of declining temperatures, which evidently caused greater numbers to seek the protection of the leaf stratum, while the latter date was in a period of rising temperature. Throughout the winter these beetles were found in the leaf stratum in increased numbers on warm, sunny days, indicating a vertical migration according to temperature. Phytonomus nigrirostris is an introduced species, coming from Europe, and was first collected in Illinois by Mr. W.P. Flint in 1919.

The large numbers of beetles in the late summer and autumn collections were mostly due, evidently, not to species feeding and breeding in the forest, but to forest border and prairie species which migrate forestward in preparation for hibernation. Many of the leaf-beetles belonging to the forest proper also hibernate, but in no case were the numbers taken in random sampling sufficiently large to warrant the construction of frequency polygons illustrating their relative abundance. The question of how far into a larger forest species such as these would penetrate for hibernation is unanswered. It is probable that the distance would vary with different species, but the tract of woodland studied was too small to afford a solution of this problem. The typical sequence of events, insofar as indicated by the collections is about as follows.

In most of the species considered the stimulus initiating

migration seems to be the gradual increase, in late summer and early autumn, in the daily range in temperature, caused by lower night temperatures. Some species seem to require the additional stimulus of a frost of greater or less intensity, while others which appear in the forest very early seem not to require this stimulus. The disappearance or maturation of the food plant may be a factor in some cases, or hibernation may follow a period of abundance of food. The most of the beetles, in the present instance, appeared in maximum numbers between September 26 and October 3, a period characterized by falling temperatures and a marked drop in the night minimum.

In the forest, the beetles appear first in large numbers in the stratum corresponding to that in which the summer portion of their life history is spent. If the principal summer food plant is found in the high forest margin, the first appearance is in the shrub stratum. If the summer habitat is the low forest margin or meadow, the insects first appear in the herb stratum. A downward migration follows under the stimulus of an additional fall in temperature or additional frosts. Insects from the shrub stratum seem, in most cases, to spend a short period of time in the intermediate herb stratum before seeking the final place of hibernation in the leaf or soil strata. Warm days may reverse the course of migration at any point, and even in winter, high temperatures bring hibernating insects nearer to the surface, so that they are taken in greater numbers under such conditions. Thus, in most cases considered, at least, the definition of hibernation as used by Baumberger (1917), that of a period of quiescence persisting after a rise in temperature, does not apply.

Hemiptera
Cicadellidae

Certain leaf-hoppers exhibited phenomena very similar to those discussed for the beetles. The frequency polygons of Plate XIX represent the numerical relations in this group. These polygons are not solid, as those in the previous plates, but otherwise the manner of representation is similar. No attempt is made to represent the strata in which these insects occurred.

Empoasca viridescens Walsh.

The leaf-hopper named above was not noted at all until September 19, and appeared in very large numbers on September 26, principally in the herb stratum, but to a lesser extent in the shrub stratum. It was swept from these strata in very large numbers during a period of about six weeks, the largest numbers occurring on September 26 and October 31. The intervening period was marked by low temperatures, which probably caused the insects to retire to more sheltered locations. Leaf-hoppers are also known to migrate downward to the base of herbage during dry weather, so that the numbers obtained by random sweeping are less under such weather conditions. After December 1, no Cicadellidae were found elsewhere than in the leaf stratum and in the soil below. They were more abundant in the collections on warm days when they could be seen moving about above the surface of the leaf layer. They emerge very early in the spring, as soon as food plants are available.

Erythroneura obliqua Say (and varieties)

The frequency curve for this leaf-hopper, in almost all points is similar to that for the form just discussed. The first maximum occurred a week later and the second maximum was relatively higher.

Only a few were found in the herb and shrub strata, and practically all were taken from the leaf stratum. Greater numbers of this species were taken throughout the winter than of the preceding.

Frequency polygon "t" of Plate XIX indicates the occurrence of all species of Cicadellidae. As will be seen, it is, for the greater part of its length, merely an expression of the sum of the two polygons previously discussed. It indicates, however, the occurrence of a few individuals of other species during the summer. Two or three other species were also observed in small numbers in hibernation during the winter.

Araneae

Uloborus americanus Walck. Plate XX

The frequency polygons illustrating the occurrence of this spider is in two parts, the heavy line representing the adults and the light line the juveniles. Adults, at first more abundant than the young, disappeared entirely after October 17. The first young were taken August 22, and increased rapidly in numbers until October 17 after which they, also, disappeared from the collections. This species hibernates when half-grown, reaching maturity in early summer. The young spiderlings emerge from the egg in the latter part of July.

Dictyna Plate XX

Most of the young spiders of this genus probably belonged to the species volupis, but were too young for positive identification. The web of this spider is made in the hollow of a slightly rotted leaf, where the eggs are deposited in July. Young and half-grown individuals were abundant August 29, and the largest numbers for the season were taken on October 3. The numbers then declined,

and after October 24 none were found except in hibernation in the leaf stratum. As was the case with the beetles and leaf-hoppers, these spiders were found more abundantly on the warm winter days.

Tetragnatha Plate XXI

Adults and young of this genus were not found together, as the former appeared in the collections only in the very early part of the season, none at all being found after the second week in July. The young appeared first on October 24, and first became abundant on November 21. The maximum occurred on December 19. These spiders were found almost invariably in the shrub and herb strata, very few being found in the lower strata even during the very cold weather. Hibernation, in Tetragnatha, simply means seeking a somewhat sheltered place in a crevice in the bark or some similar location, for a few hours or days when weather conditions are very unfavorable. As soon as the air becomes slightly warmer, the spiders emerge and again become active.

Epeira gibberosa Hentz. Plate XXI

This species was the most abundant spider during the later summer months, reaching a maximum during the week of August 29. None were found after November 7. This species does not hibernate in the adult stage, but eggs are deposited during the early autumn.

Cocoons of this species are formed from the small folded leaves of shrubs, the petioles of which are reenforced by strands of silk and which are lined and fastened together at the edges with silk. These cocoons became very numerous after October 15. One other unknown species forms similar cocoons, generally in larger leaves and at a greater height from the ground. The eggs hatch within a month or so after deposition, and the young pass the

winter in the cocoon, to emerge in the spring. Experiments to be detailed later indicate that there is a period of dormancy after the emergence from the egg of the young spider, and that, although favorable conditions may bring about emergence from the cocoon of spiders which have not been subjected to prolonged low temperatures, those which have experienced such temperatures emerge more quickly upon the return of favorable conditions.

The cocoons are very heavily parasitized by a hymenopterous insect, Arachnophaga picea Riley. Of 52 cocoons examined on January 9, 22 were found to have been parasitized by some organism which had already emerged, and four were found to contain hymenopterous larvae, of which there were, in each case, two. Of 350 cocoons used in experiments, 47 produced from one to five individuals of A. picea. In the greater number of cases, there were two insects, one male and one female, in each cocoon. Single individuals of each of two other species also emerged from other cocoons of the same lot.

Epeira Plate XXI

Figure 1 of this plate illustrates, first, by the heavy line, the occurrence of adults of Epeira hortorum Hentz, and second, the occurrence of young, probably of this species. Adults were found on August 29 and October 10. The young were abundant after September 5 and were found persistently, although not as abundantly, throughout the winter. Like Tetragnatha, they were found, not in the leaf and soil strata, but on herbage.

Acrosoma rugosa Hentz Plate XXII

This conspicuous spider was very much in evidence during the late summer. Only a single male, the importance of which is

considerably exaggerated in the figure, was taken on July 11. While the females must have been as abundant at this time as later they did not reach their greatest prominence until the end of August. After this the numbers decreased rapidly, and the last one was taken October 10. This species does not hibernate in the adult stage, but passes the winter in the egg. The small solid polygon in Plate XXII, Figure 3, indicates the date of observation of A. spinea Hentz, two individuals of which were taken August 15.

Xysticus elegans Keys. Plate XXII

Adults were found in small numbers during the earlier part of the season, the last on October 10. The young were very numerous throughout the summer and the greater part of the winter. Maxima were evident on August 1 and October 17. After the latter date none were found in the herb stratum whence the majority were taken during the summer. A large number also appeared from hibernation on February 20 and 27, after the ground had been warmed by a series of warm days.

Anyphaena rubra Emer. Plate XX

Spiders presumably of this species, mostly immature, were taken throughout the season, the maximum number being recorded for October 17, mostly in the herb and shrub strata prior to November 14, and in the leaf stratum after that date. Adults mature in early summer and hibernation takes place in the half-grown state. Large numbers were taken from rolled leaves during October. An increase in the number of individuals in the collections was noted during the warm weather of the latter part of February.

Dendryphantes aestivalis Emer. Plate XX

The frequency polygon for this species is almost exactly the

same, except for a slightly earlier appearance of the young, as that of Uloborus previously discussed. In the latter part of the season, many young were found in rolled leaves, evidently in preparation for hibernation.

Linyphia phrygiana Koch

Young of this species were abundant during the entire summer and autumn. The last to be swept from the shrub stratum were observed on November 28. A hibernating individual was found in the upper soil layer on December 12, and specimens were again found on low herbage as early as January 9. As this species matures in April and May, adults had almost entirely disappeared by July.

The spiders listed above, unlike the beetles present in sufficient numbers to allow consideration under this head, are permanent residents of the forest, instead of forms coming to the forest mainly for purposes of hibernation. In some cases the frequency polygons expressing the relative abundance of certain species of spiders seem quite similar to those of the beetles, with the maximum somewhat less abrupt. The rise here, however, was not due to an inward migration of the species but to the growth of the young spiderlings and, in some cases, to their migration through a relatively short distance to the location in which they were taken. The species having this form of curve are those which spend the hibernation period as approximately half-grown juveniles, and mature early the next year. In many instances adults were not present in the collections at all, due to their early period of maturity. The species of this group (Dendryphantes aestivalis, Uloborus americana, Anyphaena rubra, Dictyna volupis and Xysticus elegans constitute a unit in so far as adjustment to the climatic rhythm

of the temperate deciduous forest is concerned, as the differences in their annual cycle are small and relatively unimportant. Another less homogeneous group is exemplified by Acrosoma rugosa and Epeira gibberosa, which spend the winter within the egg case. In these the life cycle is much the same except that the period of dormancy comes earlier in the life of the individual, and the period of maturity comes later in the summer. Tetragnatha, Linyphia phrygiana and Epeira hortorum belong, loosely, to a third group, differing mainly in the degree of activity during the winter. Tetragnatha seems also to show a more rapid rate of development, or perhaps more continuous development through the winter, as indicated by the earlier maturity and the later appearance of the young.

IV. EXPERIMENTAL RESULTS

1. Reactions of Animals in Gradients.- In spite of their many points of unsuitability for experimental work, spiders were chosen for the experiments involving gradients in environmental conditions. This was done because of the very definite stratification of certain species. Practically all of the web-building species show rather narrowly limited stratal relations. As examples the height above the ground of the web of the following species taken in the area considered may be cited:

Species	Average Height	Maximum Height	Minimum Height
Acrosoma rugosa	1.25 M	2.25 M	0.3 M.
Acrosoma spinea	0.7 M		
Linyphia phrygiana	1.5 M	3.0 M	0.3 M
Anyphaena	1.25 M	3.0 M	0.3 M

Species	Average Height	Maximum	Minimum
Uloborus americanus	0.7 M	2.0 M	0.3 M
Epeira gibberosa	0.7 M	2.0 M	0.3 M
Hyptiotes cavatus	1.0 M	1.5 M	0.3 M

These averages are all based on a large number of collections, with the exception of Acrosoma spinea, and the latter is included here only for comparison with A. rugosa. According to Shelford (1913) this species is usually found still lower.

Of the species mentioned above only a part were suitable, on account of abundance, size, and other characteristics, for prolonged experimentation. Faults for this purpose of some of the species sufficiently abundant were small size, pugnacity, sluggishness, tendency to build a maze of web in the experimental cage or to make a silken retreat in a corner of the cage no matter what the conditions of the air might be. One familiar with the behavior of spiders will readily supply additional difficulties inherent in most species.

The first series of experiments, undertaken with Acrosoma rugosa only, was an attempt to determine directly, if possible, the relation of various factors to the height at which webs of the species are built. In a preliminary experiment ten spiders were placed in a small screen cage 45 cm. high and left over night on a table in the laboratory. The next morning all had built webs, seven of them within two inches of the top, and the other three all in the upper half. The cage was then reversed and one hour later all individuals had begun webs in the upper half of the cage.

In Experiment 7-19 (Table XI) ten individuals were placed under inverted battery jars 33 cm. by 45 cm. high on a laboratory

table. Strips of corrugated paper were supplied for foot-hold, and the upper two-thirds of one was covered with black paper. Observations were then made every two minutes and the positions of the spiders were recorded. The spiders consistently sought the upper part of each cage, regardless of the partial darkness in the one. Light does not seem to be a determining factor.

For Experiment 8-0 eighteen spiders were placed in a 6-foot screen cage in the laboratory dark-room late in the afternoon after having been brought from the field. The next morning 10 were between 5 and 6 feet from the floor, 4 between 2 and 3 feet from the bottom, and 3 on or near the bottom of the cage. The wooden cross-bars at the bottom, at 3 feet, and at the top afforded good points of attachment for webs. Of 44 spiders similarly placed in the cage at night, 30 were found the next morning at the top, 9 halfway up, and 5 at the bottom. This experiment indicates that the selection of the position for the web takes place almost, if not quite as well in darkness as in light, and is largely governed by architectural conditions.

Observations in the field showed that the most favorable situation for a web of this species is a leafless shrub with lateral branches near enough to another point of attachment to make possible the characteristic structure of the web. If the dead shrub supplies a suitable point of departure the spider may swing across to the other side and thus carry across the first line of the web, or otherwise a thread is spun which is carried by an air current across the intervening space, becomes attached because of its viscous nature, and thus forms a bridge across which the spider may travel. Spiders often attempt to establish webs where there is no

possibility of success by either method. Fruitless attempts several hours in duration may be made to establish a web from a seemingly suitable point of departure, and free lines several meters in length may be spun in the attempt to find a second point of attachment.

Additional experiments with A. rugosa included the observation of the reactions of the species in gradients of the evaporating power of air and of temperature. Experiments 1, 2, 3, 3a, 7, and 7a illustrate the former, and Experiments 9, 9a, 10 and 10a are examples of the latter. Detailed results of the experiments involving evaporation gradients are recorded in Table XII. In these experiments the cages and air conditioning apparatus described by Shelford and Deere (1913) and Shelford (1914) and previously used by the author (1917, 1919) was utilized. The evaporating power of the air, in the experiments involving this factor, was taken before and after the experiments by passing the air current over standardized atmometers. The figures given at the heads of the columns indicate the evaporation from a standard atmometer for a one-hour period.

The tabulated results of these experiments show a strong tendency for the animals to seek the driest third of the cage, even when the evaporation amounts to as much as 2.8 cc. per hour. This is an evaporating power much greater than would ordinarily be encountered in the normal habitat. The maximum mean hourly evaporation observed for a one-week period was a little over 1 cc. per hour, at the forest margin in the middle of July. Assuming, on the basis of observational data, that three fourths of this evaporation took place in the day-time, we obtain the hourly mean for daylight hours of about 1.5 cc. The spider concerned is never found in this area. Figured in the same way, the maximum hourly evaporation in

the shrub stratum where this species is found could not have exceeded 1.25 cc. with the usual value much below this. The explanation of the experimental results is somewhat difficult. The only suggestion that offers itself is that the animal selects the place of highest evaporation available where other conditions are favorable. As was noted earlier, the evaporation at 1.35 M. the average height of the web of this species, is much greater than at ground level.

The records of experiments involving a gradient of air temperature are given in Table XIII. Here the results indicate an optimum air temperature of 23.5° or lower. As the lowest temperatures are found near the ground level, this factor would tend to regulate the height to which the spiders ascend but the natural vertical gradients of neither temperature nor evporation are steep enough to determine the location of the webs. In fact, as shown in Table XIV, which records the results of an experiment involving a vertical evaporation gradient, with the low evaporation in the upper part of the cage, the spiders seek a higher level even if in so doing they pass into a region of lower evaporation. Whether a difference in evaporation would determine the height to which the animal would ascend, within the limits available in the field, was of course, a question impossible of solution with the small cages, etc., available.

The tendency to seek higher levels is, within certain limits, at least, in this species independent of the evaporating power and presumably of the temperature of air. While the animal reaches and builds its web at a level at which there is a certain balance between the optima selected in the laboratory, this height seems to be determined by mechanical and structural relations rather than by

the direct effects of the conditions of the air.

Epeira gibberosa, which occurs at or near the top of the herb stratum at an average height of .7 M. was also subjected to a gradient of the evaporating power of the air. Experiments 92, a,b, and c, which are recorded in Table XV show the reactions of this spider. In contrast with Acrosoma rugosa this species showed a preference for a region of less intense evaporation, averaging about 1.8 cc. per hour, a condition somewhat approximating the maximum evaporation at the level mentioned in the more open areas of the woods. Field experiments also showed that this species exhibits a strong positive prototropism. Other experiments were not successful because of the rather small size and the ease with which the animal is injured. The experiments just outlined seem to give results which accord very closely with what one might expect from a knowledge of the habitat. The spider is found near the tops of the herbs, in the more open parts of the woods, often in full sunlight, in a region of a correspondingly high evaporation.

Immature specimens of Anyphaena sp. found at an average height of 1.25 M., often in curled leaves or in similar sheltered places, protected by a silken tube, were also subjected to gradients in temperature and evaporating power of air. Table XVI, summarizing Experiments 13, 13a, 103 and 103a illustrates the behavior of this species. The optimum temperature seems to be in the neighborhood of 20°C., and the most favorable evaporation at about 1.7 cc or less, per hour. The normal evaporation in a rolled leaf, and with the protection afforded by a silken tube, is, of course, much less than in an openly exposed web at the same height, where the maximum is probably somewhat more than the value just given. The lowest

temperature available was chosen as was the case with Acrosoma.

Dendryphantes aestivalis is a wandering spider inhabiting especially, low shrubs and small trees. On account of the lack of a web or definite retreat it is less restricted in its normal daily movements than any of the forms previously discussed. In a gradient of the evaporating power of air, as in Experiments 11, 11a and 11b, (Table XVII) while there is a preference for the drier parts of the cage with an evaporating power of 3.7 cc per hour, this preference is not marked, as in the case of Acrosoma. The larger figures for the terminal portions of the cage may be explained by the tendency of the spiders to occupy the corners.

In a gradient of air temperature, as illustrated by Experiments 101 and 101a (Table XVIII) D. aestivalis also shows a preference for the lowest temperature available. This preference is very decided when a difference of 13° between the ends of the cage is maintained and less marked when this difference is only 3°.

Temperatures much below the outdoor summer temperature could not be maintained, with a flow of air, in the apparatus, but in each case the temperature chosen by the spiders used in the experiments was much below that prevalent in the open fields. It is probable that this temperature reaction is one of the important factors limiting the distribution, horizontally, and perhaps vertically of the species considered. Evaporation seems to be of lesser importance as the spiders show a preference for an evaporation much higher than that encountered in their natural habitats. The antagonistic action of stimuli of the two kinds may be partially responsible for the phenomena of vertical distribution of spiders, but it appears that the physical environment afforted by plant structures,

together with food relations are of considerably greater importance in this respect.

3. Effect of Environmental Conditions on the Rate of Development.- In order to test the effect of temperature and humidity conditions on the time elapsing until emergence, cocoons of Epeira gibberosa Hentz* were gathered at various times during the autumn and winter, brought to the laboratory and kept under controlled conditions until the experiment was terminated on April 18. Each cocoon was placed in a short piece of glass tubing of about 5 mm. inside diameter and about 3.5 cm. long, the ends of which were closed by a loose plug of cotton. The tubes were then fastened to strips of wood in groups of ten, for the sake of easier handling, and placed in the controlled experimental cages. A complete series involving contrasting humidities at all temperatures used, and vice versa, was not available, but an attempt was made to obtain widely variant conditions in the few cages that were used. Records of the conditions in the various cages were made with the aid of recording thermographs and hygrographs, and evaporation was, in most cases, determined by the use of the porous cup atmometer. The cages BH, BW, AL and ALL (See Table XXII) were similar in every way, and the air was allowed to flow through all at the same rate. CLL was a small glass cage, while HI was an unlighted refrigeration chamber. Both were adequately ventilated, but the rate of flow of the air could not be compared with that in the other cages. All cages except HI were illuminated by daylight (passing through several thicknesses of glass) and AL and ALL were, in addition, during the day, illuminated by large nitrogen-filled daylight lamps. B was

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* This identification is tentative only.

the large constant-temperature room in which cages BH, BW and CLL were located. All temperatures in this room were approximately constant, except for a noonday rise of from three to five degrees during the last six weeks of the experimental period. Cages AL and ALL were in an adjoining room, the temperature of which was variable, simulating a simplified ideal winter day. Further details of the conditions in these experimental chambers may be obtained by the inspection of Table 22. All figures given in this table represent the means of weekly data.

As the cages could not be opened without changing, for the time being, the conditions (especially the humidity) it was desired to maintain, the cocoons were examined but once a week, at the same time that it was necessary to open the cages to change the record sheets on the recording instruments. Although an error was introduced into the calculations in this way, it is felt that the disadvantages of this procedure were not as great as those attending a more frequent disturbance of the controlled conditions.

Control lots of cocoons were placed in glass tubes in the same manner and exposed to outdoor conditions in the screen-house adjoining the glass enclosed room in which the controlled apparatus was located. In some cases cocoons were changed from one experimental chamber to another. A considerable number were from time to time transferred from less favorable conditions to the high temperature and high humidity of cage BH, or to BW, where the humidity was somewhat less.

For purposes of comparison it was assumed that the processes of development ending in emergence proceeded at a uniform rate under the same conditions, and that when a cocoon was transferred from one

set of conditions to another the amount of development taking place in each was proportional to the rate of development for that set of conditions multiplied by the time during which it was allowed to remain under those conditions. On this basis velocity factors were computed for each experimental cage. An example will suffice to illustrate the method. Comparing lots Aa and Ae (Table XX) we find that the first was left in cage HI for 69 days and then transferred to cage BH where 21 days elapsed before emergence. Lot Ae remained in cage BH, an average time of 67 days before emergence. Assuming that both lots were at the same developmental stage at the beginning of the experiment, we may derive the following algebraic equation from the data just given:

$$69\ V_{HI} + 21\ V_{BH} = 67\ V_{BH},$$

where V_{HI} and V_{BH} represent the velocity factors for cages HI and BH, respectively.

$$V_{BH} = 1.5\ V_{HI}$$

Taking the velocity factor of HI as unity, we obtain the relative value of 1.5 for V_{BH}. Similarly by comparing lots Ca and Cb, we obtain a value of 1.7. Further comparisons led to the adoption of 1.6 as an average value for V_{BH}, when compared to V_{HI} as 1.0. Similar calculations were made for the other sets of conditions, and the velocity factors given in Table XX were obtained. The sums of the products of these factors and the number of days in the corresponding cages gave values approximately constant within each group of cocoons brought from the field on the same day. The further assumption was then made that all were in the same stage of development on October 15, and the number was obtained, which, when multiplied by the number of days elapsing between October 15 and the

beginning of the experiment, and added to the number just mentioned, gave a number approaching a constant for the entire experiment. The figure thus obtained (0.65 for Epeira and 0.85 for Arachnophaga) represents the velocity factor for outdoor conditions. This does not represent, as do the other velocity factors, the relative velocity of development under a stable set of conditions, but is rather a summation of many velocity factors operating through the season. None of the velocity factors obtained in this manner should be considered as definite and exact quantities, but rather as a means by which certain relationships can be brought to the attention. For example, the real velocity factor for a certain set of conditions would depend upon the stage of development already reached by the organism and its previous physiological history. While the limitations of this method are rather obvious, it is perhaps almost equally evident that it is not limited in its application to the estimation of the comparative developmental value of experimentally controlled conditions. If we have definite knowledge as to the climatic conditions prevailing during a given series of seasons, we may tentatively develop a velocity factor for each combination of conditions. Phenological predictions made on the basis of such calculations would undoubtedly be more likely of fulfillment than those made on the basis of temperature cumulations only, or than those based on any other single factor.

With definite reservations as to the significance of the figures involved, we may proceed to the examination of Table XX, which illustrates the data obtained from the time of emergence of the spiders under the different experimental conditions. It will be seen that the most rapid development took place in Chamber BH,

with a mean temperature of 25.8° and with the air saturated with moisture. The rate in Chamber HI with a mean temperature of 18° and a mean relative humidity of 64% was about six-tenths of this, provided the cocoons were removed to BH after a period of about fifty days. If retained longer at the lower temperature (and lower humidity) the true value of the factor would be much less, as is shown by the high value of the "constant" obtained in lots Df and Fd. These results indicate that development proceeded, up to a certain point, at the low temperature and low humidity of this cage, but that a limit was reached beyond which development was very slow, with the probability of the occurrence of death in a short time. In fact, as will be seen from Table XXI, no spiders emerged unaided from cocoons kept in HI, and large numbers of well developed spiderlings were found dead in the cocoons in this cage. No spiders were able to emerge under any conditions except those of very high humidity.

Cage AL gave a velocity factor about two-thirds that of HI, with the difference that emergence was possible under the conditions prevailing here. The day temperature in AL readhed an average of 21.2 while the night temperature fell, on an average, to 1.7, while the mean was 9.3. The humidity averaged above 90%. On account of the slowness of the processes of development here not all of the spiders in this cage had emerged when the experiment closed, but even at this low temperature complete development was possible. The threshold of development for this spider is evidently very low. No preliminary period of freezing was necessary for their emergence, but the fact that the velocity factor for outdoor conditions seems to have nearly the same value throughout the winter suggests a

stimulating effect of low temperatures or of variable temperatures. Further data are necessary for the determination of the threshold of development and the point to which development may proceed at low temperatures without a high moisture content. The short time required for the emergence of the spiders from the single cocoon of lot De is unexplained. This cocoon may have been formed several weeks earlier than the others.

The percentage of cocoons producing living spiders was about the same under the conditions prevailing in cages BH and AL, and in the lots placed first in HI and then removed to BH. The highest percentage of spider-producing cocoons was found in the control lot, Bh (Table XXIII). In this lot there were no dead spiders which could be identified as such when the cocoons were opened, and fifty percent of the cocoons had either produced living spiders or still contained them at the end of the experiment.

A summary of the data from all experiments shows that the number of cocoons containing spiders, living or dead, totalled 48% of the entire number, and of 52 cocoons examined on January 9, exactly half contained living spiders while the remainder were parasitized. Thus the mortality in unparasitized cocoons may be considered as zero in the control set.

None of the experimental conditions were as favorable for normal development as were outdoor conditions, although development took place more rapidly in several of the former. It will also be seen that the outdoor conditions were much more unfavorable for the development of the parasites than those prevailing in the experimental chambers. No spiders were able to emerge, in the experimental cages, where the relative humidity averaged less than

90%, even under the most favorable temperature conditions, and at high humidity spiders were able to complete their development at a very low temperature. A variable temperature, or a period of medium temperature followed by high temperature with high humidity, seems to be more favorable than a prolonged high temperature, although the last mentioned condition produces the most rapid development. The two former conditions most closely approach those of the natural habitat of the animals.

Before the experiments involving the spider cocoons had been in progress very long, it was evident that the hymenopterous insect parasitic on the eggs of this species (Arachnophaga picea Riley) was able to reach maturity and to emerge under much more varied conditions than those favorable for the development and emergence of the spiders. Records of the emergence of these insects were made in the same way as in the case of the spiders, and the same procedure was followed in obtaining velocity factors and in computing "constants". The data thus obtained are given in Table XIX.

The most rapid development took place in lot Ba, which was brought from the field on November 8 and placed in cage HI for two months, after which it was removed to cage BH. The value of the "constant" in this case is conspicuously low, and differs markedly from those computed from the data furnished by lots Aa, Cb and Dd, which were given the same treatment in the same sequence. The only difference between lots Aa and Ba was the length of time under outdoor conditions, as the latter were brought to the laboratory eight days after the former. Before October 31, the temperature had not fallen below the freezing point of water, but a heavy frost, with a minimum temperature of -3.3° occurred the morning of November 2.

As the second lot developed so much more rapidly than the first, we must conclude that freezing was in all probability the cause of the variation. It appears, then, that the most rapid development of this insect takes place if it is subjected to freezing temperature for a short time, then to a moderate temperature for a considerable period, and finally to a high temperature. The fact that development took place in about the same time in CLL (dry) and BH (wet) seems to indicate that, at high temperatures at least, humidity is not of great importance. The "constants" obtained from lots Cb and Dd were again of the more usual magnitude, indicating that further freezing did not increase the velocity of development in the same proportion as a short time at temperatures below zero. However, the stimulating effect of low temperature or of variation was such that throughout the series the velocity factors for outdoor exposure and for cages AL and ALL were always greater than that for cage HI with a much higher mean temperature. It is also certain that humidity is a more important factor at the lower temperatures.

Insects also developed more rapidly when subjected to a moderate temperature for a time after being brought from the field, than if introduced directly to a high temperature. This will be seen by comparing the data from lots Ba and Bb, Bc and Bd. Of these the second was introduced immediately into cage BH (high temperature, high humidity), the third was introduced first into CLL (low humidity) and then into BH, while the fourth was left in CLL. All developed much more slowly than the first, which remained for two months at the lower temperature before being subjected to the high temperature and high humidity. There seemed to be no difference between the CLL-BH combination and direct introduction into BH,

while the cocoons left in CLL required an additional week.

The Time X Velocity Factor product was highest for Series A, E, and F. The higher value for the first group may be explained by assuming that without a preliminary freezing, the processes of development require a longer time. Series E and F gave high values because a longer time at low temperature did not further accelerate development.

The highest percentage of Arachnophaga picea developed from the cocoons of lot Da which were brought from the field on January 16 and immediately placed in the high temperature-moderate humidity chamber. Over 25% of the cocoons of this lot yielded parasites, while the proportion among all cocoons in this chamber was nearly as great. This high proportion was also obtained from a CLL-BH combination, at the same temperature. HI alone and BH alone were very unfavorable. It was rather remarkable that no parasites were found in the control series subjected to outdoor conditions. The parasites in that lot evidently perished in the larval stage, as no exoskeletal remains were observed. Numbers of dead imagos were found in the HI series and none emerged unaided from cocoons retained in this environment throughout the experimental period. The combination of low humidity and medium temperature in this chamber seemed to allow development up to a certain point beyond which a change of some sort was necessary to avoid death. This could not have been due entirely to low temperature, as several insects emerged in each of the variable low temperature cages. In both of these, however, the moisture content of the air was greater than in HI. Moisture seems to be of little importance for the development of Arachnophaga

at high temperatures, in fact saturated air seems to be less favorable for rapid development than air with a lower moisture content, but at low temperatures moisture becomes a limiting factor.

In only a few cases did both spiders and parasites develop from the same lot of cocoons. The lots concerned were Aa and Dd, Ab and Be. The two first mentioned were subjected to the HI-BH combination, medium temperature-low humidity followed by high temperature-high humidity, and in these the spiders completed their development in less time than the parasites. The remaining two were from cage AL, low temperature and high humidity. Here the parasites developed first, much sooner in the case of Be which had been frozen before being brought to the laboratory. The parasites are able to complete their development in a dry environment, while the spiders can not emerge unless the humidity is above 90%. While low and variable temperatures stimulate the development of both forms, this stimulus is more prominent in the case of the parasite, which also has a lower threshold of development.

V. SUMMARY AND CONCLUSIONS

1. During the summer months the mean daily temperature in the elm maple forest increases upward from the ground level at the rate of approximately 0.35°C. per ten meters, and relative humidity decreases 3.5% in the same distance. These gradients may be absent or reversed during early morning hours, and during the colder months of the year.

2. The intensity of light in the forest increases rapidly from the ground level up. At noon of a sunny day the intensity at ground level under herbage is about 0.35% that of full sunlight,

while that at 1.25 M. is about three times as great.

3. The evaporating power of the air is least at ground level, averaging, for the period of observation, 5.96 cc. mean daily evaporation from a standard porous cup atmometer, and increases upward, at first rapidly and then more slowly to a minimum of 15.71 cc. at the level of the tops of the trees.

4. Random sampling of the upper soil, leaf, herb and shrub strata showed variations of the animal population in general in inverse ratio to variations in the evaporating power of the air. This is just the reverse from conditions in the pine dune community as found by Sanders and Shelford(1922).

5. A great and sudden increase in the insect population as determined by random sampling occurred in early autumn, the maximum collections being made on October 3. This was due to the autumnal migration of hibernating species from the forest border and the adjacent meadows, which was associated with a gradual decline in temperature and an increase in the daily mean variability due to lower night temperatures. The inward migration occurred at the level of the normal summer habitat of the insects concerned and was followed by a downward migration to the place of hibernation.

6. Of non-migratory animals especial attention was given to the spiders, which may be divided into three groups according to their manner of adjustment of life history to the annual rhythm of the deciduous forest. Most species pass the winter in hibernation in the adolescent state. The second group spends the winter in the egg case, hatching either in late autumn or early spring, while the third differs from the first only in a greater degree of activity during the winter.

7. Experiments involving the reactions of spiders in gradients of the various environmental factors differing at the different levels in the forest indicate that these factors are probably of considerable importance in determining the horizontal and vertical distribution of the animals but that their relative importance is not the same for different species. Among web-building species the mechanical features of the environment as related to the support of the web are also of very great importance.

8. Cocoons of Epeira gibberosa Hentz, some of which were parasitized by Arachnophaga picea Riley were subjected to controlled atmospheric conditions, with results leading to the following conclusions:

a) High temperature (Mean 25.8°C) and a relative humidity near the saturation point caused most rapid development of the spiders, but mortality was lowest under outdoor conditions.

b) Spiders were unable to complete development or to emerge except under conditions of high humidity.

c) The parasites developed most rapidly when allowed to remain in the open until after the occurrence of freezing temperatures, then placed for two months in a low temperature-low humidity chamber (means 18.0°C and 63.9%), and finally removed to a high temperature (Mean 25.8°C) high humidity chamber. The humidity at this temperature seemed to have the effect of increasing the mortality, however, while a lower humidity (Mean 83.9%) at the same temperature produced just as rapid development.

d) Mortality of the parasites was lowest when the cocoons were kept for the greater part of the time, at least, at a high temperature and a moderate or low humidity, and greatest under outdoor

conditions.

e) The threshold of development of the parasite was found to be lower than that of the host. The host developed more rapidly, however, at high temperatures.

f) Relative velocity factors for each set of conditions were computed and the law that the summation of the products of the velocity factors by time gives a constant, was developed. This relation may be expressed as follows:

$$(T_1V_1 + T_2V_2 + \ldots\ldots\ldots\ldots\ldots + T_nV_n) = K$$

where T_1, T_2, etc. represent the length of time spent under each set of conditions and V_1, V_2, etc., represent the corresponding velocity factors. When sufficient data are available such velocity factors may be computed for any set of conditions, and for any developmental process influenced by such conditions. Results thus obtained may be utilized in phenological predictions.

9. Data obtained as indicated above have a definite relation to the adjustment of the life cycles of the animals considered to the annual climatic rhythm of the temperate deciduous forest and savanna.

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Table I

Temperature Data -- Station A, 0.6 M. above ground surface

Week endg.	Week no.	Abs. Max.	Abs. Min.	Mean Max.	Mean Min.	Mean Temp.	Base Mean	Total Range	Mean Range	Mean Range above Base
July 4	1	32.2	22.2					10.0		
July 11	2	33.3	23.3					10.0		
July 18	3	34.2	18.9	33.2	19.5	25.5	21.3	15.3	13.7	11.9
July 25	4	34.4	13.9	30.9	17.8	23.2	19.9	20.6	13.1	10.9
Aug. 1	5	33.3	14.4	29.4	19.4	23.7	21.5	19.0	10.0	7.9
Aug. 8	6	27.8	14.4	25.3	15.9	19.7	16.9	13.3	9.4	8.4
Aug. 15	7	27.5	11.7	23.7	15.5	13.4	17.2	15.8	8.2	6.6
Aug. 22	8	30.0	14.7	25.6	15.9	20.4	18.0	15.3	9.7	7.6
Aug. 29	9	33.3	15.0	27.7	20.3	21.6	20.9	18.3	7.4	6.8
Sept. 5	10	30.0	19.4	26.4	20.3	23.1	21.7	10.6	6.1	4.8
Sept. 12	11	29.2	11.7	23.2	15.1	18.9	17.3	17.5	8.1	5.8
Sept. 19	12	28.3	9.4	22.9	14.8	18.4	17.0	18 9	8.2	5.9
Sept. 26	13	27.5	8.1	27.0	15.1	18.1	15.7	19.4	11.9	11.3
Oct. 3	14	29.4	9.2	23.1	13.4	18.1	15.8	20.3	9.7	7.3
Oct. 10	15	23.3	2.2	17.5	6.5	12.0	8.7	21.1	11.1	8.8
Oct. 17	16	25.6	2.2	17.4	5.5	10.9	7.7	23.3	11.9	9.7
Oct. 24	17	25.6	4.4	20.2	7.8	12.8	9.9	21.1	12.4	10.3
Oct. 31	18	22.8	7.2	20.6	8.9	13.6	10.8	15.6	11.7	9.8
Nov. 7	19	18.3	-1.7	14.8	-0.5	6.7	2.9	20.0	15.3	11.9
Nov. 14	20	13.9	-7.8	4.4	-2.9	0.7	-0.5	21.7	7.4	4.9
Nov. 21	21	17.8	-5.0	10.5	1.4	5.8	3.8	22.8	9.1	6.7
Nov. 28	22	10.6	-3.3	7.6	2.1	4.9	4.0	13.9	5.5	3.6
Dec. 5	23	14.4	-3.3	7.0	0.6	3.3	2.3	17.8	6.4	4.7
Dec. 12	24	11.7	-6.7	6.7	-2.6	1.3	-0.8	18.3	9.3	7.4
Dec. 19	25	12.8	-10.0	6.4	-0.6	2.0	1.3	22.8	7.1	5.1
Dec. 26	26	8.6	-9.4	-1.9	-5.8	-4.0	-4.8	18.1	3.9	2.9
Jan. 2	27	3.9	-12.2	-0.7	-8.8	-4.9	-6.7	16.1	8.1	6.0
Jan. 9	28	12.8	-10.0	4.5	-5.4	-0.8	-4.1	22.8	9.9	8.6
Jan. 16	29	8.3	-15.8	-1.6	-10.6	-3.7	-7.4	24.2	9.0	5.8
Jan. 23	30	3.1	-23.3	-3.6	-13.0	-9.3	-10.0	26.4	9.4	6.3
Jan. 30	31	1.7	-19.4	-0.9	-15.7	-9.8	-14.0	21.1	14.8	13.1
Feb. 6	32	8.6	-7.5	5.2	- 3.3	0.3	-1 2	16.1	8.5	6.4
Feb. 13	33	14.2	-15.0	4.7	-4.9	-1.4	-3.3	29.2	9.6	7.9

Table II

Temperature Data -- Station B, 10 M. above ground surface.

Week ending	No. Week	Abs. Max.	Abs. Min.	Mean Max.	Mean Min.	Temp. Mean	Base Mean	Total Range	Mean Range	Mean Range above Base.
Aug. 1	5	33.3	13.9	30.5	20.9	24.6	21.4	19.4	9.6	9.1
Aug. 8	6	26.7	14.4	25.3	15.4	19.9	16.9	12.2	9.9	8.4
Aug. 15	7	28.3	9.4	24.3	15.6	19.6	17.1	18.9	8.7	7.2
AUG. 22	8	31.1	11.1	25.7	16.2	20.8	18.0	20.0	9.6	7.7
Aug. 29	9	30.6	15.0	28.1	19.7	23.4	21.0	15.6	8.4	7.1
Sept. 5	10	30.6	18.9	27.1	19.6	22.9	21.1	11.7	7.4	5.9
Sept. 12	11	26.7	11.7	24.8	14.8	19.4	17.1	15.0	10.1	7.7
Sept. 19	12	27.2	8.9	23.1	15.0	18.4	16.6	18.3	8.1	6.5
Sept. 26	13	31.7	7.2	25.1	13.9	19.2	17.1	24.4	11.2	7.9
Oct. 3	14	32.2	9.4	23.9	13.7	17.7	15.0	22.8	10.2	8.9
Oct. 10	15	29.4	0.6	17.8	5.8	11.8	8.7	28.9	12.1	9.1
Oct. 17	16	26.7	-0.6	17.3	4.9	10.1	7.2	27.2	12.4	10.1
Oct. 24	17	27.8	2.2	19.1	6.8	12.1	9.0	25.6	12.2	10.1
Oct. 31	18	26.7	0.0	19.3	9.3	13.2	11.1	26.7	10.0	8.2
Nov. 7	19	18.3	-1.7	14.2	3.3	8.2	4.8	20.0	10.9	9.4
Nov. 14	20	16.7	-3.9	6.6	-0.5	2.4	1.6	20.6	7.1	5.0
Nov. 21	21	18.9	-3.9	9.7	3.3	6.5	4.9	22.8	6.3	4.8
Nov. 28	22	12.8	-2.2	6.7	1.1	4.3	2.8	26.1	5.6	3.9
Dec. 5	23	13.9	-2.2	7.8	2.2	4.3	3.5	16.1	5.6	4.3

Table III

Temperature Data -- Soil Temperature 0.1 M. below surface of soil.

Week Ending	Week No.	Abs. Max.	Abs. Min.	Mean Max.	Mean Min.	Mean Temp.	Extreme Range	Mean Daily Range
July 4	1	20.0	18.0	19.7	18.1	18.7	2.0	1.6
July 11	2	20.2	18.3	19.9	18.3	19.0	1.9	1.6
July 18	3	20.0	18.1	19.3	18.1	18.3	1.9	1.2
July 25	4	20.0	15.6	18.0	16.8	17.4	4.4	1.2
Aug. 1	5	20.3	16.1	19.2	17.9	17.8	4.2	1.2
Aug. 8	6	18.3	15.0	16.9	16.1	16.5	3.3	0.8
Aug. 15	7	18.3	14.7	16.6	15.8	16.3	3.6	0.8
Aug. 22	8	18.3	14.4	17.0	15.6	16.2	3.9	1.4
Aug. 29	9	19.2	14.4	17.4	16.3	16.9	4.7	1.1
Sept. 5	10	19.4	17.8	19.5	18.2	18.8	1.7	1.3
Sept. 12	11	18.3	15.3	17.2	16.1	16.7	3.1	1.1
Sept. 19	12	17.2	13.9	16.7	15.0	16 1	3.3	1.7
Sept. 26	13	17.5	12.2	15.9	14.6	15.5	5.3	1.3
Oct. 3	14	18.1	11.1	15.1	13.8	13.9	6.9	1.3
Oct. 10	15	11.7	8.6	10.4	8.8	9.5	3.1	1.6
Oct. 17	16	10.8	6.1	8.6	7.6	8.1	4.7	0.9
Oct. 24	17	12.5	7.2	10.3	9.2	9.7	5.3	1.2
Oct. 31	18	12.2	9.4	11.3	10.2	1 0.6	2.8	1 2
Nov. 7	19	9.7	5.6	7.8	6.2	7.1	4.2	1.6
Nov. 14	20	6.7	0.0	3.8	2.5	3.2	6.7	1.3
Nov. 21	21	1.4	0.0	1.4	0.0	0.8	1.4	1.4
Nov. 28	22	4.4	1.7	4.0	2.9	3.3	2.8	1.1
Dec. 5	23	6.1	0.6	3 4	2.3	2.9	5.6	1.2
Dec. 12	24							
Dec. 19	25	4.7	-1.4	1.6	0.1	0.8	6.1	1.5
Dec. 26	26	0.8	-2.8	-1.4	-1.9	-1.6	3.6	0.5
Jan. 2	27	-2.8	-3.9	-2.8	-3.1	-2.9	1.1	0.3
Jan. 9	28	-2.8	-3.3	-3.1	-3.3	-3.2	0.6	0.2
Jan. 16	29	-2.8	-4.7	-3.4	-3.8	-3.6	1.9	0.4
Jan. 23	30	-4.2	-5.8	-4.5	-4.9	-4.7	1.7	0.4
Jan. 30	31	-5.8	-7.2	-6.3	-6.7	-6.5	1.4	0.4
Feb. 6	32	-3.6	-5.3	-4.1	-4.2	-4.1	1.7	0.1
Feb. 13	33	-3.3	-5.0	-3.6	-4.1	-3.8	1.7	0.4
Feb. 20	34	-3.3	-5.8	-4.4	-4.8	-4.6	2.5	0.4

Table IV

Relative Humidity Data -- Station A, 0.6 M. above ground surface

Week ending	Week No.	Abs. Max.	Abs. Min.	Mean Max.	Mean Min.	Mean R.H.	Base Mean	Total Range	Mean Range	Mean Range below Base	Mean Vapor Press. mm.Hg.
July 11	2	100.0	40.0	93.7	48.0	74.7	87.1	60.0	45.7	39.1	
July 18	3	94.0	35.0	84.1	40.4	66.1	76.5	59.0	43.7	36.1	16.20
July 25	4	95.0	35.0	86.1	41.7	68.6	79.4	60.0	44.4	37.7	14.6
Aug. 1	5	94.0	42.0	88.1	53.5	75.8	83.3	52.0	34.6	29.8	16.6
Aug. 8	6	95.0	42.0	90.0	58.5	77.6	85.2	53.0	31.5	26.7	13.3
Aug. 15	7	97.0	42.0	94.4	62.8	82.4	91.2	55.0	31.6	28.4	13.9
Aug. 22	8	100.0	64.0	98.1	70.5	86.8	92.2	36.0	27.6	21.7	14.6
Aug. 29	9	100.0	59.0	99.9	78.3	89.2	96.5	31.0	21.6	18.2	17.4
Sept. 5	10	100.0	61.0	99.8	78.0	93.2	97.7	39.0	21.8	19.7	19.7
Sept.12	11	100.0	52.0	97.5	62.5	87.5	91.2	48.0	35.0	28.7	14.4
Sept.19	12	99.0	58.0	95.7	71.5	87.2	91.2	41.0	24.2	19.7	13.8
Sept.26	13	100.0	47.0	95.1	58.0	82.3	90.2	53.0	37.1	32.2	12.8
Oct. 3	14	100.0	43.0	96.0	62.1	84.1	91.9	57.0	33.9	29.8	13.1
Oct. 10	15	100.0	55.0	96.9	63.3	81.8	90.9	45.0	33.6	27.6	8.6
Oct. 17	16	100.0	46.0	96.0	56.0	76.1	90.8	54.0	40.0	34.8	7.4
Oct. 24	17	100.0	49.0	95.5	54.4	77.9	87.8	51.0	41.1	33.4	8.6
Oct. 31	18	100.0	41.0	100.0	63.0	88.6	97.4	59.0	37.0	34.4	10.4
Nov. 7	19	100.0	39.0	96.0	44.4	75.5	91.3	61.0	51.6	46.9	5.6
Nov. 14	20	100.0	59.0	95.5	73.3	88.1	92.5	41.0	22.2	19.2	4.2
Nov. 21	21	100.0	52.0	98.1	77.0	91.3	95.3	48.0	21.1	18.3	6.3
Nov. 28	22	100.0	60.0	99.3	85.3	94.5	97.6	40.0	14.0	12.3	6.2
Dec. 5	23	100.0	68.0	98.7	77.0	92.1	97.4	32.0	21.7	20.4	5.4
Dec. 12	24	100.0	63.0	99.4	72.7	90.8	96.4	37.0	26.7	23.7	4.6
Dec. 19	25	100.0	50.0	93.0	60.3	82.5	87.7	50.0	32.7	27.4	4.4
Dec. 26	26	100.0	57.0	95.3	81.8	91.4	93.5	43.0	13.5	11.7	3.0
Jan. 2	27	95.0	38.0	86.3	57.7	79.3	82.0	57.0	28.6	24.3	2.4
Jan. 9	28	100.0	47.0	86.0	60.5	78.5	83.9	53.0	25.5	23.3	3.4
Jan. 16	29	100.0	48.0	87.4	58.8	74.0	81.3	52.0	28.6	22.5	2.5
Jan. 23	30	100.0	50.0	91.7	63.1	81.2	88.4	50.0	28.6	25.3	1.7
Jan. 30	31	98.0	51.0	91.8	56.7	79.3	85.7	47.0	35.1	29.0	1.6
Feb. 6	32	100.0	43.0	92.4	63.3	81.3	86.7	57.0	29.1	23.4	3.8
Feb. 13	33	100.0	48.0	92.3	55.8	80.3	86.2	52.0	36.5	30.4	3.3

Table V

Relative Humidity Data -- Station B, 10 M. above ground surface

Week ending	Week No,	Abs. Max.	Abs. Min.	Mean Max.	Mean Min.	Mean R.H.	Base Mean	Total Range	Mean Range	Mean Range below Base Mean
Aug. 22	8	94.0	58.0	93.1	59.8	79.0	88.7	36.0	33.3	28.9
Aug. 29	9	100.0	62.0	96.3	68.8	84.9	92.8	38.0	27.5	24.0
Sept. 5	10	100.0	57.0	100.0	69.5	90.2	95.4	43.0	30.5	25.9
Sept.12	11	97.0	47.0	97.0	61.0	83.3	91.6	50.0	36.0	30.6
Sept.19	12	90.0	35.0	88.0	55.3	77.5	86.2	55.0	32.7	30.9
Sept.26	13	90.0	34.0	89.6	47.8	73.4	84.6	56.0	41.8	36.8
Oct. 3	14	97.0	38.0	95.4	56.0	81.0	92.2	59.0	39.4	36.2
Oct. 10	15	100.0	45.0	98.8	54.5	79.1	88.4	55.0	44.3	33.9
Oct. 17	16	100.0	42.0	95.1	52.3	75.1	86.4	58.0	42.8	34.1
Oct. 24	17	100.0	41.0	100.0	64.4	88.6	95.9	59.0	35.6	31.5
Oct. 31	18	100.0	40.0	92.0	50.0	73.6	82.2	60.0	42.0	32.2
Nov. 7	19	97.0	36.0	93.4	46.4	73.4	87.4	61.0	47.0	41.0
Nov. 14	20	100.0	62.0	98.0	72.0	86.9	92.4	38.0	26.0	20.4
Nov. 21	21	100.0	50.0	96.3	80.1	91.8	92.6	50.0	16.2	12.5
Nov. 28	22									
Dec. 5	23	100.0	60.0	96.0	70.0	85.7	92.0	40.0	26.0	22.0
Dec. 12	24	100.0	47.0	99.1	63.4	86.0	92.7	53.0	35.7	29.3
Dec. 19	25	100.0	34.0	94.3	58.0	81.9	87.4	66.0	36.3	29.4
Dec. 26	26	100.0	66.0	96.5	82.3	91.3	93.6	34.0	14.2	11.3
Jan. 2	27	100.0	23.0	96.0	52.5	77.5	80.8	77.0	43.5	28.3
Jan. 9	28	100.0	49.0	84.1	56.0	74.2	78.2	51.0	28.1	22.2
Jan. 16	29	100.0	35.0	86.7	49.8	68.5	76.7	65 0	36.9	26.9
Jan. 23	30	100.0	38.0	92.3	57.7	79.9	85.8	62.0	34.6	28.1
Jan. 30	31	96.0	46.0	91.5	51.0	75.5	82.3	50.0	40.5	31.3
Feb. 6	32	100.0	48.0	93.4	50.7	76.5	83.0	52.0	42.7	32.3
Feb. 13	33	100.0	42.0	94.3	50.4	77.5	84.7	58.0	43.9	34.3

Table VI

Diurnal Variations in Light Intensity in the Forest as Determined by the Macbeth-Evans Illuminometer August 29-30, 1921

At Ground Level

Time	Reading	Factor Daylight Screen	Factor Absorption Screen	Intensity in Foot-Candles	Intensity in Meter-Candles
Aug. 30					
8:00-8:10 A.M.	5	1.9	0	9.5	102
9:00-9:10	7.6	1.9	0	14.4	155
10:00-10:10	5.5	1.9	0	10.5	113
1:00 P.M.	1.4	1.9	13.2	35.0	378
Aug. 29					
3:10 P.M.	9.0	1.9	0	17.0	184
4:25 P.M.	5.2	1.9	0	10.0	107
5:15	2.1	1.9	0	4.0	43

Table VII

Diurnal Variations in Light Intensity in the Forest as Determined with the Macbeth-Evans Illuminometer. August 29-30, 1921.

At 1.25 M. above ground

Time	Reading	Factor Daylight Screen	Factor Absorption Screen	Intensity in Foot-Candles	Intensity in Meter-Candles
Aug. 30					
8:00-8:10 A.M.	9.0	1.9	0	17	180
	8.0	1.9	0	15 16	160 170
9:00-9:10	1.12	1.9	13.2	28	300
	20.0	1.9	0	38 33	410 355
10:00-10:10	2.8	1.9	13.2	70	760
	2.4	1.9	13.2	60 65	650 705
12:30-12:40 P.M.	1.46	1.9	43.2	120	1290
	3.9	1.9	13.2	100 110	1050 1170
Aug. 29					
2:45 P.M.	20.0	1.9	0	38	410
2:55-3:00	1.53	1.9	13.2	38	410
	18.0	1.9	0	34 37	370 430
4:05-4:10	10	1.9	0	19	200
	11	1.9	0	21 20	220 210
5:00-5:10	5	1.9	0	10	100
	4.4	1.9	0	8 9	90 95
6:10-6:15	9	1.9	0.0757	1.3	14

Table VIII

Diurnal Variations in Light Intensity in a Forest Glade as Determined with the Macbeth-Evans Illuminimeter. August 29-30, 1921

At 1.25 M. above ground

Time	Reading	Factor D.L. Screen	Factor Absorption Screen	Light Intensity in Foot-Candles		Light Intensity in Meter-Candles	
Aug. 30							
7:20 A.M.	13.0	1.9	43.2	106	106	1140	1140
7:50-8:00	12.0	1.9	169	3850		41480	
	14.0	1.9	169	4495	4175	48390	44940
9:00-9:10	6.0	1.9	670	7640		82220	
	21	1.9	169	6740	7190	72580	77400
10:00-10:10	6.0	1.9	670	7640	7640	82220	82220
12:30-12:40 P.M.	7.8	1.9	670	9930		106880	
	25	1.9	169	8030	8980	86410	96650
Aug. 29							
2:40 P.M.	5.8	1.9	670	7770	7770	83660	83660
4:45-4:50	5.5	1.9	169	1765		19010	
	18.5	1.9	43.2	1520	1645	16350	17680
5:50-5:55	3.1	1.9	43.2	255		2740	
	2.7	1.9	43.2	220	240	2390	3570
6:00	5.8	1.9	13.2	145	145	1570	1570

Table 9.

Evaporation Data, as Obtained from Porous Cup Atmometers

Sta. No.		1	2	3	4	5	6	7	8	9	10	11
Height (M)		1.0	0.1	1.5	1.5	2.5	0.15	0.15	6.0	10.0	12.0*	0.15
Date	Wk.	Average daily evaporation in cc.(reduced to standard)										
Jun.30		x	x	x	x	x	x	x				
Jly. 2		11.1										
Jly. 4	1	12.0	7.5	12.6	11.0	13.7	2.4	20.9				
Jly.11	2	13.6	8.5	14.3	14.3	14.9	7.6	20.7				
Jly.18	3	19.1	13.0	19.4	19.4	20.2	7.6	24.8	x			
Jly.25	4	14.8	9.7	15.3	15.3	16.2	10.2	24.9		x		
Aug. 1	5	13.9	9.5	15.2	14.6	15.1	8.6	#	19.6	15.4		
Aug. 8	6	7.9	5.0	8.3	8.6	9.0	2.8		10.7	10.9	x	x
Aug.15	7	6.6	4.7	7.7	7.8	7.8	2.6		9.7	10.8	12.2	8.8
Aug.22	8	8.1	5.0	8.1	8.2	9.0	2.8		10.1	10.1	11.2	8.1
Aug.29	9	4.6	2.8	4.6	4.8	5.7	1.3		7.7	6.9	@	6.2
Spt. 5	10	4.4	2.9	5.5	5.4	5.7	1.7		4.6	8.9	6.3	6.5
Spt.12	11	4.3	2.5	4.6	4.4	5.0	1 3		6.7	6.9	10.1	6.3
Spt.19	12	5.0	3.9	5.9	6.0	6.6	1.6			7.7	13.9	5.1
Spt.26	13	7.6	4.2	8.4	7.7	8.9	3.3		10.6	8.7	12.0	5.1
Oct. 3	14	7.0	4.8	8.8	7.9	8.6	3.3		9.3	9.2	14.1	6.3
Oct.10	15	8.6	5 5	9.9	9.0	9.6	5.0		9.4	9.3	8.7	6.7
Oct.17	16	11.6										
Oct.24	17	15.2										
Oct.31	18	11.0										
Nov. 7	19	13.6										
Nov.14	frozen											

X -- atmometer set up on this date. First reading includes evaporation beginning on this date.

* -- atmometer changed to another tree at 15 M. height on September 5.

\# -- atmometer stolen and observations at this station discontinued. See Station 11.

@ -- atmometer moved on this date to a height of 15 M. in another tree.

Location of Stations:

1 -- top of instrument shelter
2 -- on ground under shrubs
3 -- south side of tree trunk
4 -- north side of tree trunk
5 -- suspended under leafy maple branch
6 -- in hollow stump
7 -- at west edge of woods, short grass
8 -- in tree
9 -- in tree
10 -- at level of tree tops
11 -- at east edge of woods, tall grass

Table 10.

Animal Population of the Lower Strata of University Woods

July, 1921 to February, 1922

Week Ending	Week No.	Soil Str. Col.	Soil Str. Ave.	Leaf Str. Col.	Leaf Str. Ave.	Herb Str. Col.	Herb Str. Ave	Shrub Str. Col.	Shrub Str. Ave	Total	Per Acre (thousands)	Per Hect
July 4	1	1	11	2	24.5	3	9.	3	.6	45.1	500	1212
July 11	2	1	16	1	20	6	13.5		#2.	51.5	571	1384
July 18	3	1	10	1	14	3	15	3	4.8	43.8	486	1177
July 25	4	1	15	2	5	3	8.4		4.2	32.6	362	876
Aug. 1	5	3	14.7	1	11		11.5		3.9	41.1	457	1105
Aug. 8	6	2	14.5	1	12	3	14	3	3.6	44.1	489	1185
Aug.15	7											
Aug.22	8	1	18	1	15	3	8	2	4.5	44.5	499	1196
Aug.29	9	1	19	1	21	5	5.8	1	1	46.8	519	1258
Sept.5	10		14.5		32	5	18.2	5	3.4	68.1	756	1831
Sept.12	11	1	10	1	43	1	22	1	15	90	999	2419
Sept.19	12	1	17	1	24	1	30	1	15	86	955	2312
Sept.26	13		15		60	2	54	2	78.5	207.5	2203	5578
Oct. 3	14		13	1	133	1	283	1	69	498	5527	13387
Oct. 10	15											
Oct. 17	16		7	1	49	1	128	1	24	208	2309	5591
Oct. 24	17											
Oct. 31	18	1	27	1	146	1	25	1	14	212	2353	5699
Nov. 7	19	1	16	1	125	1	23	1	5	169	1876	4543
Nov. 14	20		12	1	85		20		4.5	121.5	1349	3266
Nov. 21	21	1	8	1	54	1	16	1	4	82	910	2204
Nov. 28	22	1	14	1	33	1	37	1	9	93	1032	2500
Dec. 5	23	1	1	1	36	1	11	1	0	48	533	1290
Dec. 12	24	1	13	1	51	1	2	1	0	66	733	1774
Dec. 19	25	1	5	1	22	1	16	1	0	43	477	1156
Dec. 26	26											
Jan. 2	27	1	3	1	34	1	8	1	0	45	500	1210
Jan. 9	28	2	5.5	1	58	1	4	1	0	67.5	749	1814
Jan. 16	29	1	3	1	15	1	0	1	0	18	200	484
Jan. 23	30			1	22							
Jan. 30	31			1	22							
Feb. 6	32	1	7	1	90	1	3	1	0	10	111	269
Feb. 13	33	1	7	1	10	1	0	1	0	17	189	457
Feb. 20	34	1	6	1	16	1	10	1	0	23	256	618
Feb. 27	35	1	7	1	29	1	0	1	0	36	400	968

Table XI

Experiment No.7-19. Showing the reactions of the spider Acrosoma rugosa Hentz, in a vertical light gradient*

Minutes from	Control			Experiment		
3:40 P.M.	1	2	3	1	2	3
0	5	0	0	5	0	0
2	0	1	4	0	5	
4	1	0	4	1+	4	
6	0	0	5	1	4	
8	0	0	5	0	5	
10	0	0	5	1	4	
12	0	0	5	1	4	
14	0	1	4	1	4	
16	1	2	2	1	4	
18	1	1	3	1	4	
20	0	2	3	1	4	
22	0	1	4	1	4	
24	0	1	4	0	5	
26	0	1	4	0	5	
28	0	1	4	0	5	
30	0	1	4	0	5	
60	0	1	4	0	5	
120	0	1	4	0	5	
Totals	8	14	68	9	76	
		82				

*Five spiders were placed in each of two inverted glass battery jars 45x33 cm., one of which (experiment) was covered with black paper on the top and the upper two-thirds of the sides. The other was uncovered, and both stood on a laboratory table receiving light from a North window 3 M. distant. The spiders had been brought from the field the previous day. Temperature of the room was 80°F.

Table 12

Experiments 1, 2, 3, 3a, 7 and 7a. Showing the reactions of the spider *Acrosoma rugosa* Hentz in gradients of the evaporating power of air.*

Exp. No.	1			2			3			3a			7			7a		
Evap.	0.0	0.2	2.2	2.5	1.2	0.08	0.2	1.2	2.3	2.3	1.4	0.5	0.5	1.4	2.8	2.8	1.4	0.5
Temp.	24.5°	26.5°	25.5°	24.5°	26.5°	25.5°	21.5°	22°	21.5°	21.5°	22°	21.5°	24°	24°	24°	24°	24°	24°
Minutes																		
0	0	0	0	2	2	2	2	2	2	2	2	2	3	4	3	3	4	3
1	0	4	2	2	2	2	2	1	3	2	1	3	4	2	4	8	1	1
2	0	3	3	2	2	2	1	2	3	3	1	2	5	1	4	8	0	2
3	0	3	3	2	2	2	2	1	3	3	1	2	3	3	2	8	0	2
4	0	2	4	2	3	1	2	1	3	2	3	1	2	6	2	8	0	2
5	0	2	4	2	4	0	2	1	3	3	2	1	3	3	4	8	0	2
6	0	2	4	2	3	1	2	2	2	4	1	1	3	3	4	8	0	2
7	0	1	5	2	3	1	2	2	2	4	1	1	4	1	5	6	0	4
8	0	0	6	2	4	0	2	1	3	4	1	1	4	1	5	6	0	4
9	0	0	6	2	4	0	2	1	3	4	1	1	3	4	3	5	2	3
10	0	1	5	2	3	1	2	2	2	4	1	1	4	2	4	6	0	4
11	0	1	5	2	3	1	2	1	3	4	1	1	4	4	2	5	0	5
12	1	0	5	3	1	2	3	1	2	3	2	1	2	5	3	5	2	3
13	2	0	4	3	1	2	3	1	2	4	1	1	3	4	3	6	1	3
14	2	1	3	3	2	1	2	1	3	3	1	2	2	5	3	5	2	3
15	2	1	3	3	2	1	2	1	3	3	2	1	4	4	2	6	1	3
16	2	1	3	3	2	1	2	1	3	3	1	2	4	3	3	6	1	3
17	2	0	4	3	1	2	2	1	3	4	0	2	5	2	3	6	1	3
18	2	1	3	3	1	2	2	1	3	3	2	1	5	1	4	7	0	3
19	2	1	3	3	2	1	2	0	4	4	1	1	2	5	3	7	2	1
20	3	0	3	3	2	1	2	0	4	5	1	0	3	3	4	7	1	2
21	1	2	3	3	2	1	2	0	4	5	0	1	2	2	6	6	2	2
22	2	1	3	3	2	1	2	0	4	4	1	1	2	5	3	7	0	3
23	2	1	3	3	2	1	1	1	4	3	2	1	3	3	4	7	2	1
24	2	1	3	3	2	1	1	1	4	3	0	3	3	3	4	7	1	2
25	2	1	3	3	2	1	1	0	5	5	0	1	2	3	5	6	1	3
26	2	1	3	3	2	1	1	1	4	5	0	1	2	3	5	6	1	3
27	1	1	4	3	2	1	2	2	2	4	0	2	2	3	5	5	2	3
28	1	1	4	3	2	1	1	2	3	4	1	1	2	3	5	5	1	4
29	1	1	4	3	2	1	3	0	3	3	1	2	2	2	6	4	4	2
30	1	2	3	3	2	1	2	1	3	3	1	2	2	3	5	7	1	2
31	2	2	2	3	2	1	2	1	3	3	1	2	2	3	5	7	2	1
32	1	3	2	4	1	1	3	0	3	3	2	1	1	3	6	7	1	2
33	2	2	2	4	1	1	2	1	3	3	1	2	1	2	7	7	1	2
34	3	0	3	3	2	1	2	2	2	2	1	3	1	3	6	8	0	2
35	3	0	3	3	2	1	2	2	2	4	1	1	1	3	6	7	1	2
36	3	0	3	3	2	1	2	1	3	5	0	1	1	4	5	6	2	2
37	3	0	3	3	2	1	1	2	3	3	3	0	1	3	6	7	0	3
38	3	0	3	3	2	1	1	2	3	3	2	1	1	2	7	8	1	1
39	3	0	3	4	1	1	1	2	3	3	1	2	1	4	5	7	1	2
40	3	0	3	4	1	1	1	2	3	3	1	2	2	3	5	7	1	2
Total	59	43	138	113	83	44	74	45	121	140	44	56	103	124	173	262	39	99

Summary	Exp. No.	Net	Medium	Dry
	1	59	43	138
	2	44	83	113
	3	74	45	121
	3a	56	44	140
	7	103	124	173
	7a	99	39	262
Totals		435	378	947
Percent		24.7	21.5	53.8

*Animals were placed in the gradient cage, distributed as indicated after the figure "0" in the "minutes" column, and observations of their positions recorded at one-minute intervals. The evaporating power of the air flowing through each of the three sections of the cage is given at the heads of the respective columns, expressed in cc. per hour evaporated from a standard atmometer. The temperature in centigrade degrees is indicated in the next line.

Table XIII

Experiments 9, 9a, 10 and 10a. Showing the reactions of the Spider Acrosoma rugosa Hentz in gradients of Air Temperature*

Expt. No.	10			10a			9			9a		
Temp. (Centigrade)												
	23.5	26.0	27.5	28.5	27.0	26.0	35	33	29	33	35	36
Minutes												
0	3	4	3	3	4	3	3	4	3	3	4	3
1	6	2	2	2	3	5	2	4	4	7	1	2
2	6	2	2	1	0	9	1	3	6	7	1	2
3	6	3	1	1	3	6	1	2	7	7	0	3
4	6	3	1	1	2	7	2	3	5	7	0	3
5	6	3	1	3	3	4	2	3	5	7	0	3
6	5	4	1	2	4	4	1	3	6	7	0	3
7	5	5	0	1	4	5	3	1	6	7	0	3
8	6	4	0	1	4	5	4	1	5	7	0	3
9	6	4	0	2	3	5	4	2	4	6	1	3
10	8	2	0	1	3	6	4	2	4	7	0	3
11	5	3	2	1	3	6	2	2	6	7	0	3
12	6	3	1	0	5	5	2	3	5	5	1	4
Temp.	23.5	26.0	27.5	29	27	26	34.5	33	29.5	32	35	36
13	6	3	1	1	3	6	1	2	7	4	2	4
14	7	0	3	1	2	7	1	1	8	3	3	4
15	7	1	2	0	4	6	1	2	7	6	1	3
16	7	2	1	1	2	7	0	3	7	5	2	3
17	5	3	2	1	3	6	0	4	6	4	3	3
18	5	3	2	1	4	5	2	2	6	5	2	3
19	6	2	2	1	3	6	0	4	6	4	2	4
20	5	3	2	1	3	6	0	3	7	6	1	3
Temp.	23.5	26	28	29	27	26						
21	4	3	3	0	2	8	0	3	7	6	1	3
22	6	3	1	0	3	7	0	2	8	5	1	4
23	8	1	1	0	5	5	0	1	9	5	1	4
24	7	0	3	0	4	6	0	1	9	4	2	4
25	6	1	3	0	4	6	0	2	8	4	3	3
26	6	2	2	0	4	6	0	3	7	5	2	3
27	6	2	2	0	3	7	0	3	7	6	3	1
28	5	3	2	1	2	7	1	2	7	7	2	1
29	8	0	2	1	3	6	1	2	7	8	1	1
30	6	2	2	2	3	5	0	2	8	9	0	1
Temp.	24	26.5	28.5	29	27	25.5	34	33	30	32	35	36
Totals												
	181	72	47	27	94	179	35	71	194	177	36	87
Percent.												
	60.3	24.0	15.7	9.0	31.3	59.7	11.7	23.7	64.6	59.0	12	29

* Animals were placed in the cage, distributed as indicated opposite the figure "0" in the minutes column, and observations of their positions recorded at one-minute intervals. The temperatures, as indicated by thermometers placed in the cage, are given at the heads of the respective columns, and at intervals in the columns as the temperatures changed.

Table XIV

Experiment 8. Showing the Reactions of Acrosoma rugosa Hentz in a vertical gradient of the evaporating power of air*

	Experiment 8		
	Bottom Section	Middle Section	Top Section
Evap.	2.5cc	1.4cc	0.7cc
Temp.	26	26	26
Minutes			
0	8	0	0
1	7	1	0
2	4	3	1
3	4	2	2
4	5	2	1
5	4	3	1
6	3	3	2
7	3	2	3
8	4	2	2
9	4	0	4
10	3	2	3
11	3	1	4
12	2	2	4
13	2	1	5
14	2	1	5
15	2	3	3
16	2	2	4
17	2	2	4
18	1	3	4
19	1	3	4
20	1	3	4
21	2	2	4
22	2	2	4
23	1	2	5
24	3	1	4
25	2	3	3
26	0	2	6
27	2	1	5
28	1	2	5
29	1	1	6
30	1	2	5
31	1	3	4
32	1	2	5
33	1	3	4
34	1	3	4
35	1	3	4
36	1	3	4
37	1	3	4
38	2	1	5
39	2	2	4
40	2	1	5
Total	87	83	150

*Eight animals were placed in the lower third of the same cage used in previous experiments, set on end, and observations of their positions were recorded at one-minute intervals. The evaporating power of the air expressed in cubic centimeters of water evaporated from a standard atmometer in one hour is indicated at the head of each column, and the temperature in degrees centigrafe of the corresponding third of the cage is recorded just below.

Table XV

Experiments 92, 92a, 92b, 92c.* Showing the Reactions of the Spider Eweira gibberosa Hentz in gradients of the evaporating power of air.**

Exp.No.	92			92a			92b			92c		
Evap.	1.1	1.8	3.0	3.0	1.8	1.1	1.3	2.1	2.7	2.7	2.1	1.3
Temp.	24	24	24	24	24	24	24	24	24	24	24	24
Minutes												
0	3	2	3	3	2	3	4	3	4	3	5	3
1	3	5	0	2	4	2	4	4	3	3	5	3
2	3	4	1	2	1	5	5	3	3	4	5	2
3	5	3	0	1	2	5	4	5	2	3	6	2
4	4	4	0	2	2	4	4	5	2	3	6	2
5	4	4	0	2	4	2	4	5	2	3	6	2
6	4	4	0	2	2	4	4	5	2	3	6	2
7	4	4	0	2	3	3	4	5	2	3	6	2
8	5	3	0	2	3	3	4	5	2	3	6	2
9	5	3	0	2	3	3	4	5	2	4	5	2
10	5	3	0	2	3	3	3	6	2	4	5	2
11	5	3	0	2	3	3	4	5	2	4	5	2
12	5	3	0	2	3	3	4	5	2	4	5	2
13	5	3	0	2	3	3	4	5	2	4	5	2
14	5	3	0	2	3	3	4	5	2	4	5	2
15	5	3	0	2	3	3	4	5	2	4	5	2
16	5	3	0	2	3	3	4	5	2	4	5	2
17	5	3	0	2	3	3	4	5	2	4	5	2
18	5	3	0	2	3	3	4	5	2	4	5	2
19	5	3	0	2	3	3	4	5	2	4	5	2
20	5	3	0	2	3	3	4	5	2	4	5	2
Totals	92	67	1	39	57	64	80	98	42	73	106	41

Summary

Expt.No.	Wet	Medium	Dry
92	92	67	1
92a	64	57	39
92b	80	98	42
92c	73	106	41
Totals	309	328	123
Percent of Total	40.7%	43.1%	16.2%

* All experiments designated by the same arabic numeral were performed with the same group of animals. In the present instance, three more were added for experiments 92b and 92c.

** See Table XII for method of conducting the experiments and recording results.

Table XVI

Experiments 13, 12a, 103, and 103a. Showing the reactions of *Anyphaena sp.* in gradients of evaporating power of air and air temperature*

Exp. No.	103			103a			12			12a		
Evaporation							3.7	2.8	1.8	1.8	2.8	3.7
Temperature	20	25	29	29	25	20	23	23	23	23	23	23
Minutes					**							
0	2	2	2	4	0	2	1	1	1	1	1	1
1	2	3	1	4	0	2	0	1	2	1	0	2
2	2	3	1	4	0	2	0	1	2	1	1	1
3	5	0	1	4	0	2	0	1	2	1	1	1
4	3	1	2	4	0	2	0	1	2	1	2	0
5	3	1	2	4	0	2	0	1	2	1	2	0
6	3	1	2	4	0	2	o	1	2	1	1	1
7	3	1	2	4	0	2	0	1	2	1	1	1
8	3	1	2	4	0	2	0	1	2	1	1	1
9	3	1	2	4	0	2	0	1	2	1	1	1
10	3	1	2	4	0	2	0	1	2	1	1	1
11	3	1	2	3	0	3	0	1	2	1	1	1
12	3	1	2	3	0	3	0	1	2	0	1	2
13	2	2	2	3	0	3	0	0	3	0	2	1
14	4	0	2	3	0	3	0	0	3	1	0	2
15	4	0	2	2	1	3	0	0	3	1	0	2
16	2	2	2	3	0	3	0	0	3	1	0	2
17	2	2	2	2	0	4	0	0	3	1	0	2
18	2	3	1	2	0	4	0	0	3	1	0	2
19	3	1	2	2	0	4	0	0	3	1	0	2
20	3	1	2	2	0	4	0	0	3	2	0	1
21	3	1	2	2	0	4	0	0	3	2	0	1
22	3	1,	2	2	0	4	0	0	3	2	0	1
23	3	1	2	2	0	4	0	0	3			
24	3	1	2	2	0	4	0	0	3			
25	3	1	2	2	0	4	0	0	3			
26	3	1	2	2	0	4	0	0	3			
27	3	1	2	2	0	4	0	1	2			
28	2	1	3	2	0	4	1	0	2			
29	2?	1	3	2	0	4	1	1	1			
30	2	1	3	2	0	4	Tot. 2	14	71	23	15	28
31	2	1	3	2	0	4				71	14	3
32	2	1	3	2	0	4				94	29	30
33	2	0	4	2	0	4				61.4%	18.9%	19.7%
34	4	0	2	2	0	4	20°	25°	29°			
35	4	1	1	2	0	4	119	44	77			
36	4	1	1	2	0	4	134	1	105			
37	4	1	1	2	0	4	253	45	182			
38	4	1	1	2	0	4	53.7%	9.3%	38%			
39	4	1	1	2	0	4						
40	4	1	1	2	0	4						
Total	119	44	77	105	1	134						

*See Tables XII and XIII for methods.

**Continuation of Expt. 103

TABLE XVII

Experiments 11, 11a and 11b. Showing the reactions of the spider Dendryphantes aestivalis Emerton in gradients of the evaporating power of air*

Expt. No.	11	11		11a			11bb**		
Evap.	3.7	2.8	1.8	1.8	2.8	3.7	3.7	2.8	1.8
Temp.	23	23	23	23	23	23	23	23	23
Minutes									
0	1	1	1	1	1	1	2	0	1
1	0	2	1	1	0	2	3	0	0
2	0	1	2	0	1	2	3	0	0
3	0	2	1	0	1	2	2	1	0
4	1	1	1	0	1	2	1	1	1
5	3	0	0	1	1	1	1	0	2
6	2	0	1	2	1	0	1	0	2
7	2	0	1	1	1	1	1	0	2
8	2	0	1	0	1	2	1	0	2
9	2	0	1	0	0	3	1	1	1
10	2	0	1	1	0	2	1	1	1
11	2	0	1	1	0	2	1	1	1
12	0	1	2	1	0	2	1	1	1
13	0	0	3	1	0	2	1	0	2
14	0	1	2	1	1	1	1	1	1
15	1	0	2	1	0	2	2	0	1
16	1	0	2	1	0	2	2	1	0
17	0	1	2	0	1	2	2	0	1
18	1	1	1	0	0	3	2	0	1
19	2	0	1	0	1	2	1	1	1
20	1	0	2	0	1	2	1	0	2
21	0	1	2	1	1	1	1	0	2
22	1	2	0	2	1	0	2	0	1
23	2	0	1	3	0	0	2	1	0
24	1	0	2	2	0	1	2	1	0
25	1	0	2	0	1	2	2	0	1
26	1	1	1	0	0	3	1	2	0
27	3	0	0	0	0	3	2	0	1
28	2	0	1	0	1	2	1	2	0
29	2	0	1	2	0	1	3	0	0
30	1	0	2	3	0	0	2	0	1
31	0	1	2	3	0	0	2	0	1
32	2	0	1	1	1	1	2	0	1
33	2	1	0	1	0	2	2	1	0
34	3	0	0	0	0	3	2	1	0
35	3	0	0	0	1	2	3	0	0
36	2	1	0	2	0	1	2	0	1
37	1	0	2	1	1	1	2	0	1
38	0	2	1	1	0	2	2	0	1
39	2	0	1	1	1	1	2	0	1
40	2	0	1	2	0	1	2	0	1
Total	53	19	48	38	19	63	68	17	35

Summary

Exp. No.	Wet	Med.	Dry
11	48	19	53
11a	38	19	63
11b	35	17	68
Totals	121	55	184
	33.6%	15.3	51.1

* For methods of conducting experiments and recording results see Table XII.

** Continuation of Experiment 11a

Table XVIII

Experiments 101 and 101a Showing the reactions of the spider D
Dendryphantes aestivalis Emerton in gradients of air temperature

Experiment No.	101			101a		
Temperature	25°	30°	37°	25°	26°	28°
Minutes						
0	0	3	0	0	3	0
1	3	0	0	0	3	0
2	1	2	0	2	1	0
3	0	2	1	0	0	3
4	1	1	1	1	0	2
5	1	2	0	1	1	1
6	2	1	0	1	1	1
7	3	0	0	1	1	1
8	2	1	0	1	1	1
9	3	0	0	1	1	1
10	3	0	0	1	1	1
11	1	2	0	1	1	1
12	2	1	0	1	1	1
13	2	0	1	2	1	0
14	2	11	0	2	1	0
15	3	0	0	2	1	0
16	3	0	0	2	0	1
17	2	1	0	2	0	1
18	2	1	0	2	0	1
19	3	0	0	2	0	1
20	3	0	0	2	0	1
21	3	0	0	2	0	1
22	3	0	0	2	00	1
23	3	0	0	2	0	1
24	3	0	0	2	0	1
25	3	0	0	2	0	1
26	3	0	0	2	0	1
27	3	0	0	2	0	1
28	3	0	0	2	0	1
29	3	0	0	2	0	1
30	3	0	0	2	0	1
31	3	0	0	2	0	1
32	3	0	0	2	0	1
33	3	0	0	2	0	1
34	2	1	0	2	0	1
35	2	0	1	2	0	1
36	1	2	0	2	0	1
37	2	1	0	2	0	1
38	3	0	0	2	0	1
39	3	0	0	2	0	1
40	1	1	1	2	0	1
Totals	95	20	5	67	15	38

Summary

25°	30°	37°
95	20	5
79.2%	16.7%	4.1%

25°	26°	28°
67	15	38
55.8%	12.5%	31.7%

Table XIX

Length of time to emergence of *Arachnophaga picea* Riley under various conditions

Lot	Date begun	Date trans.	Date emer.	Cages 1	Cages 2	Time (days) (means)			Total no. days x veloc. fact.	Average
						0	1	2		
Aa	10/31	1/8	2/12	HI	BH					
	10/31	1/8	3/26	HI	BH	16	69	56	113.8	
Ab	10/31		3/5	AL						
	10/31		4/18+	AL		16	146.5(?)		120.0	
Ac	10/31		3/5	CLL		16	124		125.2	
Ad	10/31		4/18+	ALL		16	169+		131.8+	120.7
Ba	11/8	1/8	1/22	HI	BH					
	11/8	1/8	1/29	HI	BH					
	11/8	1/8	1/29	HI	BH					
	11/8	1/8	2/12	HI	BH	24	61	26.2	85.64	
Bb	11/8		2/12	BH		24	96		116.4	
Bc	11/8	1/8	2/12	CLL	BH					
	11/8	1/8	2/12	CLL	BH	24	61	35	110.3	
Bd	11/8		2/12	CLL						
	11/8		2/19	CLL						
	11/8		2/19	CLL		24	103		113.1	
Be	11/8		2/19	AL						
	11/8		3/26	AL		24	120.5		116.8	114.1
Bf	11/8		3/26	ALL		24	138		117.0	105.3
Ca	1/9		2/12	BH		86	34		107.1	
Cb	1/9	2/26	3/12	HI	BH	86	48	14	117.8	112.5
Da	1/16		2/12	BW						
	1/16		2/12	BW						
	1/16		2/19	BW						
	1/16		2/19	BW						
	1/16		2/19	BW						
	1/16		2/19	BW						
	1/16		3/5	BW						
	1/16		3/5	BW						
	1/16		3/5	BW						
	1/16		3/5	BW						
	1/16		3/12	BW		93	39.7		118.8	
Db	1/16		2/19	B		93	34		110.1	
	1/16		2/19	B						
Dc	1/16		2/19	CLL		93	34		110.1	
Dd	1/16	2/26	3/12	HI	BH	93	48	14	123.8	117.3
Ea	1/30	2/9	3/5	R	BW	106	10	24	122.6	122.6
Fa	1/30	2/9	2/19	R	BH					
	2/6	2/9	3/5	R	BH					
	2/6	2/9	3/12	R	BH	113	3	21.7	120.3	
Fb	2/6	2/9	3/5	R	BW					
	2/6	2/9	3/5	R	BW	113	3	24	122.6	
Fc	2/6	2/9	3/5	R	B					
	2/6	2/9	3/5	R	B	113	3	24	122.6	121.6

Table XIX (contd.)

Explanation of Table

Column Heading

Lot: Experiments whose lot number is designated by the same capital letter were begun at the same time, and the cocoons used were gathered on the same day. The lower case letters indicate groups receiving the same treatment throughout.

Date: The first date is the date on which the experiment was begun. If there is a date in the second column it indicates that on that date the cocoon was transferred from the first experimental cage to the second. The date in the third column is the date on which emergence was observed. As observations were made weekly (to avoid more frequent disturbance of the experimental conditions by more frequent opening of the cages) these dates are in most cases one week apart. The date "4/18+" indicates that living parasites were found in the cocoons when the experiment was discontinued on the date given.

Cages: In the first column is indicated the cage into which the cocoon was first introduced, and, if a transfer was made, the second column indicates the second cage. The letter "R" indicates that the cocoon was kept in the laboratory for the period indicated, before being placed in one of the experimental cages. The conditions prevailing in each of the experimental cages are given in Table XXII.

Time: In the column with the heading "0" is given the number of days elapsing between October 15 and the beginning of the experiment. It was assumed that all eggs had been deposited previous to this date, and that all were in approximately the same developmental stage at that time. In columns "1" and "2" are given the average number of days in the corresponding experimental cages.

Total number of days x velocity factor: In this column are given the numbers obtained by multiplying the number of days in each cage by the velocity factor for that cage, and adding the results. This velocity factor represents the mean relative velocity of the developmental processes in the cage concerned, and was obtained by a comparison of the data obtained from the different lots. The rate of development in Cage BW, in which the largest number developed to maturity was taken as unity.

Velocity factors used in the computations were as follows:

O	-- 0.85	HI	--0.64	AL	-- 0.80	CLL	-- 0.90
R	-- 0.85	BH	--1.00	ALL	-- 0.70	B	-- 0.90

Average: In this column are given the averages of the products in the preceding column. These averages (and the products in the preceding column) are nearly constant.

This sign indicates an average which includes the item similarly indicated in the preceding column. The unmarked average just above does not include this item.

Table XX

Length of time to emergence of Epeira gibberosa Hentz under various conditions

Lot	Date begun	Date trans.	Date emer.	Cages 1	Cages 2	Time (days) 0	Time (days) 1	Time (days) 2	Total no. days x veloc. fact.	Average
Aa	10/31	1/8	1/29	HI	BH	16	69	21	113.2	
Ab	10/31		4/18+	AL						
	10/31		4/18+	AL		16	169+		120.3+	
Ae	10/31		1/1	BH						
	10/31		1/15	BH		16	67		118.3	118.1
Be	11/8		4/9	AL						
	11/8		4/18+	AL						
	11/8		4/18+	AL						
	11/8		4/18+	AL		24	165(?)		122.9	
Bg	11/8		1/1	BH						
	11/8		1/8	BH		24	56.5		106.6	117.5
Ca	1/9		2/26	BH						
	1/9		2/12	BH		86	41		121.9	
Cb	1/9	2/26	3/5	HI	BH					
	1/9	2/26	3/12	HI	BH					
	1/9	2/26	3/12	HI	BH					
	1/9	2/26	3/12	HI	BH					
	1/9	2/26	3/19	HI	BH	86	48	14	126.4	
Cc	1/9		3/26	AL						
	1/9		4/9	AL						
	1/9		4/18	AL						
	1/9		4/18+	AL		86	90		114.4	121.2
Dd	1/16	2/26	3/5	HI	BH					
	1/16	2/26	3/5	HI	BH					
	1/16	2/26	3/12	HI	BH					
	1/16	2/26	3/12	HI	BH					
	1/16	2/26	3/12	HI	BH					
	1/16	2/26	3/12	HI	BH	93	41	11.7	120.3	120.3
De	1/16		1/29	BH		93	13		81.4	
Df	1/16		4/18+	HI		93	92+		*152.5	119.4
Eb	1/30	2/9	2/26	R	BH					
	1/30	2/9	2/26	R	BH	108	10	17	112.6	112.6
Fd	2/6	2/9	4/18+	HI		114	3	68+	146.6*	*146.6

For explanation of this Table, see Table XIX

Velocity factors: For the computations in this table the following velocity factors were used:

0 -- 0.65 HI -- 1.00 BH -- 1.61 AL -- 0.65
R -- 1.50

* This figure should be larger, as the spiders had not yet emerged when the experiment had closed.
See Table XIX.

Table XXI

Viability of the spider Epeira gibberosa Hentz and its hymenopterous parasite Arachnophaga picea Riley under various conditions

Lot	Cages 1	Cages 2	Dates begun	trans.	end.	Numbers S	P	DS	DP	E	Egg	Percents S	P	M
Ae	BH		10/31		4/18	2	0	2		6				
Bb	BH		11/8		4/18	2	1	5		12				
Ca	BH		1/9		4/18	2	1	3		4				
De	BH		1/16		4/18	1	0	1		8				
Eb	R	BH	1/30	2/9	4/18	4	1	0		5				
						11	3	11		35		18%	5%	77%
Aa	HI	BH	10/31	1/8	4/18	1	2	4		3				
Ba	HI	BH	10/8	1/8	4/18	0	4	2		4				
Cb	HI	BH	1/9	2/26	4/18	5	1	6		8				
Dd	HI	BH	1/16	2/26	4/18	6	1	0		3				
						12	8	12		18		24	16	60
Af	HI		10/31		4/18	0	0	7	3	8	2			
Bh	HI		11/8		4/18	0	1*	4	3	2	0			
Cd	HI		1/9		4/18	0	0	4	1	5	0			
Df	HI		1/16		4/18	1*	0	8	0	1	0			
Fd	R	HI	2/6	2/9	4/18	1*	0	6	1	1	1			
						2	1	29	8	17	3	3	2	95
Da	BW		1/16		4/18	0	11	19	0	10				
Ea	R	BW	1/30	2/9	4/18	0	1	5	0	4				
Fb	R	BW	2/6	2/9	4/18	0	3	6	0	1				
						0	15	30	0	15		0	25	75
Ab	AL		10/31		4/18	2	1	11	0	6	0			
Be	AL		11/8		4/18	4	3	1	1	1	0			
Cc	AL		1/9		4/18	3	0	0	1	5	1			
						9	4	12	2	12	1	23	10	67
Ad	ALL		10/31		4/18	0	1	4	1	4	0			
Bf	ALL		11/8		4/18	0	1	3	2	3	1			
						0	2	7	3	7	1	0	10	90
Ac	CLL		10/31		4/18	0	1	6	0	3	0			
Bd	CLL		11/8		4/18	0	5	7	0	7	1			
Cd	CLL		1/9		4/18	0	0	10	0	10	0			
Dc	CLL		1/16		4/18	0	1	5	0	4	0			
						0	7	28	0	24	1	0	12	88
Bc	CLL	BH	11/8	1/8	4/18	0	5	7	0	7	1	0	25	75
Db	B		1/16		4/18	0	2	0	0	2				
Fc	R	B	2/6	2/9	4/18	0	0	8	1	2				
						0	2	8	1	4		0	13	87

Table XXI (Contd.)

Explanation of Table

Column Headings

Lot: The lot numbers given here correspond to those given in the preceding tables.

Cages: As in Tables XIX and XX. Conditions in the cages are given in Table XXII.

Dates: As in Tables XIX and XX. All cocoons which had not yielded either spiders or parasites were opened on April 18, and their contents examined.

Numbers:

S: Number of cocoons yielding living spiders. In this and the next column the asterisk (*) indicates living animals not yet emerged from the cocoon on April 18.
P: Number of cocoons yielding living parasites
DS: Number of cocoons containing dead spiders on April 18.
DP: Number of cocoons containing dead parasites on April 18.
E: Number of cocoons empty or containing remains which could not be positively identified.
Egg: Number of cocoons containing unhatched spider eggs.

Percents:

S: Percentage of cocoons yielding living spiders
P: Percentage of cocoons yielding living parasites
M: Percentage total mortality (including Empty, Dead Spiders, Dead Parasites, and Eggs).

Table XXII

Conditions in experimental cages referred to in Tables XIX, XX, XXI.

Cage	Temperature (degrees C.)			Relative Humidity (Percent.)			Evap. power of air (cc. per hour)
	Max.	Min.	Mean	Max.	Min.	Mean	Mean
BH	30.0	21.0	25.8	100%		100%-	0.04
HI	19.5	16.5	18.0	69.5	56.7	63.9	0.52
BW	30.0	21.0	25.8	92.8	68.0	83.9	0.78
AL	21.2	1.7	9.3	98.2	86.8	93.6	
ALL	21.2	1.7	9.3	97.0	57.7	78.2	
CLL	30.0	21.0	25.8				1.00
B	30.0	21.0	25.8				1.00

Table XXIII

Time to Emergence of Epeira gibberosa Hentz under outdoor conditions

Lot Bh

Date begun: 11/8

Date emerged: 4/20 4/25 4/25 4/25 4/25+ 4/25+
4/25+ 4/25+

Cages: Outdoors -- otherwise treated like cocoons referred to in Tables XIX and XX.

Time in days (estimated total mean): 195

Total Number of Days x Velocity factor (as used in Table XX): 126.8

Total number of cocoons yielding living spiders:	10
Total number of cocoons yielding living parasites:	0
Total number of cocoons yielding dead spiders:	0
Total number of cocoons yielding dead parasites:	0
Total number of cocoons "Empty":	10

Percent. Spiders: 50%

Percent. Parasites: 00

Percent. Total Mortality 50

Tables XXIV - XXXIII

Summary of Collections according to Date.

The species are given in the first column, and following this are thirty-six columns representing the weeks during which collections were made. The date of the last day of each week and the number of the week are given at the head of each column. The letters opposite the name of the species indicate the situation in which the animals were found, as follows:

G -- Soil Stratum

L -- Leaf Stratum

H -- Herb Stratum

S -- Shrub Stratum

T -- Tree Stratum

R -- Rolled Leaf

St -- On Stump

Table XXIV -- Mollusca, Araneae

Table XXV -- Araneae, continued

Table XXVI -- Araneae, concluded

Table XXVII -- Insecta -- Coleoptera

Table XXVIII -- Coleoptera, continued

Table XXIX -- Coleoptera, concluded, Corrodentia

Table XXX -- Hymenoptera (Formicidae), Hemiptera & Cicadellidae).

Table XXXI --Diptera

Table XXXII -- Diptera, continued

Table XXXIII -- Diptera, concluded, Hemiptera (Fulgoridae)

Table XXIV

Species.	Date -- July 4	July 11	July 18	July 25	Aug. 1	Aug. 8	Aug. 15	Aug. 22	Aug. 29	Sept. 5	Sept. 12	Sept. 19	Sept. 26	Oct. 3	Oct. 10	Oct. 17	Oct. 24	Oct. 31	Nov. 7	Nov. 14	Nov. 21	Nov. 28	Dec. 5	Dec. 12	Dec. 19	Dec. 26	Jan. 2	Jan. 9	Jan. 16	Jan. 23	Jan. 30	Feb. 6	Feb. 13	Feb. 20	Feb. 27	Mar. 6
Week No.--	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Mollusca =																																				
Polygyra thyroides (Say)	..	LH	GL	H	..	H	..	SH	H	..	H	S	H																							
Circinaria concava (Say)	..	..	..	G	..	H	..	..	..	..	L	L	..	L	..	L	..	..	..	..	..	L	..	..	..	..	..	G								
Vitrea indentata (Say)	..	LH	..	L	..	..	..	..	..	L	L	L	..	L	..	L	..	L	L	L	..	L	L	..	..	..	..	..	L							
Zonitoides arborea (Say)	L	..	..	..	..	L	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Z. minuscula (Binney)	L	L	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	L	..	..	..	..	..	..	..	..	..
Agriolimax agrestis (Linn.)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	L	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Sphyradium edentulum (Drap.)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	H	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Phylomycus carolinienssis (Bosc.)	..	..	..	..	..	..	..	..	SH	..	..	..	..	..	..	..	..	G	L	L	..	L	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Succinea avara Say	..	G	..	..	..	..	..	..	..	..	..	..	..	L	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Bifidaria pentodon (Say)	..	L	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Vertigo milium (Gould)	..	..	..	..	..	..	..	..	..	..	..	..	..	H	..	H	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Carychium exiguum (Say)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	L	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Araneae																																				
Agelenidae																																				
Hahnia agilis Keys.	L	..	..	L																																
Hahnia cinerea Emer.	..	..	..	..	..	..	..	G	..	L	..	..	..	..	..	L	..	LL	..	..	..	..	..	..	..	..	..	..	..	L	..	L				
Agelena naevia Walck.	..	..	..	..	..	..	..	..	..	HL	HL	..	..	HL	..																					
Cicurina *f.*	..	..	..	..	..	..	..	..	..	G	..	..	L	..	..	..	..	..	..	..	..	L	..	..	..	..	..	..	..	..	L	..	..	..	..	..
Cicurina arcuata Keys.	..	..	..	..	..	..	..	..	..	..	..	..	L	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	L	..	..	L	..	..
Attidae																																				
Phidippus multiformis Emer.	..	H	..	H																																
P. tripunctatus Emer.	..	..	..	..	..	..	..	..	..	..	..	..	..	H	..	R	F	..	L																	
Phidippus *f.*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..		H																			
Zygoballus bettini Peck.	..	..	..	H	..	..	..	H	H	S	..	..	H	..																						
Attidae *f.*	..	..	..	H	..	..	..	..	..	..	..	..	H																							
Dendryphantes aestivalis Emer.	..	..	..	..	..	H	..	H	HS	S	TH	S	HR	H	R	SH																				
Habrocestum pulex Hentz.	..	..	..	..	..	..	..	..	S	..	S																									
Habrocestum *f.*	..	..	..	..	..	..	..	..	..	..	L	L																								
Naevia vittata Hentz	..	H	..	..	..	..	..	..	H																											
Plexippus puerperus Peck.	..	..	..	..	..	..	..	..	..	..	..	H																								
Mala palmarum Hentz	..	..	..	..	..	..	..	..	..	..	..	..	..	L																						
M. mitrata Hentz	..	..	..	..	..	..	..	..	..	..	..	..	..	..	R	..	..	..	S																	

Table XXV

Species	Week No.	July 4	July 11	July 18	July 25	Aug. 1	Aug. 8	Aug. 15	Aug. 22	Aug. 29	Sept. 5	Sept. 12	Sept. 19	Sept. 26	Oct. 3	Oct. 10	Oct. 17	Oct. 24	Oct. 31	Nov. 7	Nov. 14	Nov. 21	Nov. 28	Dec. 5	Dec. 12	Dec. 19	Dec. 26	Jan. 2	Jan. 9	Jan. 16	Jan. 23	Jan. 30	Feb. 6	Feb. 13	Feb. 20	Feb. 27	Mar. 6
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Aranеae -- continued.																																				
Epeiridae																																				
Tetragnatha sp?	..	H	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	S	..	SH	..	LH	SH	LH	..	H	..	..	H	..	..	..	..	..	..	H
Epeira gibberosa Hentz	..	H	H	L	..	H	..	H	H	H	H	H	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Epeira sp? *j.*	..	H	H	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	H	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Epeira *j.* *(hortorum?)*	..	..	..	..	..	..	..	..	..	..	S	S	..	..	..	S	SH	..	..	..	..	H	..	..	..	..	..	..	..	..	..	..	..	..	..	..
E. hortorum Hentz	..	..	..	..	..	..	..	..	..	H	..	..	..	..	..	S	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
E. domiciliorum Hentz	..	..	..	..	..	..	..	S	S	..	S	..	..	..	..	S	..	..	..	..	..	..	..	S	..	..	..	..	..	..	..	..	..	..	..	..
E. insularis Hentz	..	..	..	..	..	..	..	..	..	..	S	S	..	..	..	S	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
E. strix Hentz	..	..	..	..	..	..	..	..	..	..	..	..	R	..	..	R	S	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
E. prompta Hentz *j.*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	S	..	..	..	..	..	..	..	S	..	..	..	..	..	..	..	..	..	..	..	..
E. cornigera Hentz	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	S	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Acrosoma rugosa Hentz.	..	H	..	..	..	SH	..	H	S	..	..	S	..	..	R	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
A. spinea Hentz	..	..	..	..	..	S	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Argiope aurantia Lucas	..	..	..	..	..	H	..	..	..	..	..	H	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Linyphidae																																				
Linyphia phrygiana Koch *j.*	..	H	H	..	..	S	..	..	S	..	S	T	H	..	R	..	..	S	S	..	S	S	..	G	..	..	..	..	H	..	..	..	..	..	..	H
L. communis Hentz *j.*	..	..	..	..	..	..	..	..	..	..	H	S	..	..	..	S	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Erigone sp? *females*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	L	L	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Lephthyphantes sp?	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	G	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Micrometa cornupalpis Camb.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	L	..	..	..	..	..	..	..	..	..	..	..	..
Lycosidae																																				
Pardosa *j.*	..	HG	L	..	L	..	..	..	T	..	..	..	..	L	..	..	..	..	L	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Lycosa *j.*	..	..	..	G	..	G	..	..	G	..	G	..	..	..	..	G	..	G	..	..	..	..	..	..	..	..	..	..	L	..	L	..	..	..	L	G	L
Pirata *j.*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	G	..	..	..	..	..	..	..	..	..	..	L	..	..	..	..	..	..	..	..
Mimetidae																																				
Mimetus interfector Hentz	..	..	..	..	..	..	..	..	..	..	..	..	H	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Pisauridae																																				
Pisaura *j.*	..	H	..	..	..	..	..	..	..	..	..	..	..	H	..	..	..	..	..	H	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Pisaura undata Hentz	..	H	H	..	S	H	..	H	H	..	HS	H	SH	H	..	H	..	..	HG	..	..	..	..	..	..	L	..	..	..	..	..	L	..	..	..	..	..
Dolomedes *j.*	..	H	..	G	..	H	..	..	H	..	S	S	H	..	..	..	..	..	..	..	..	..	..	..	..	H	..	..	..	..	..	..	..	..	..	..	..
Dolomedes idoneus Mont.	..	..	H	..	..	..	..	..	St	..	..	..	..	..	..	L	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table XXVI

Species.	Week Ap.--	July 4	July 11	July 18	July 25	Aug. 1	Aug. 8	Aug. 15	Aug. 22	Aug. 29	Sept. 5	Sept. 12	Sept. 19	Sept. 26	Oct. 3	Oct. 10	Oct. 17	Oct. 24	Oct. 31	Nov. 7	Nov. 14	Nov. 28	Dec. 5	Dec. 12	Dec. 19	Dec. 26	Jan. 2	Jan. 9	Jan. 16	Jan. 23	Jan. 30	Feb. 6	Feb. 13	Feb. 20	Feb. 27	Mar. 6
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Araneae -- continued																																			
Clubionidae																																			
Phrurolithus alarius Hentz		..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	L																
Phrurolithus *immature*		..	..	L	..	..	H	..	..	..	..	..	G	..	..	..	..	..	..	..	..	..	L													
Clubiona *immature*		..	..	..	..	..	..	H	..	..	..	..	..	R	..	..	S	..	L	.H	..	..	..	..	..	..	..	..	..	..	..	..	..	L		
Castaneira bivittata Keys.		..	..	..	..	..	..	..	L	..	..	..	L	..	L	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	L			
Anyphaena *immature*		..	..	H	..	..	S	..	..	HS	..	..	SHL	SH	H	R	SH	..	SH	..	L	G	..	..	..	..	..	..	L	..	..	L	..	L	..	
Anyphaena rubra, Emer.		..	..	..	..	..	..	..	..	..	..	..	..	..	..	R	S	..	..	..	..	..	..	..	..	..	..	..	..	L						
Dictynidae																																			
Dictyna *immature*		..	..	..	..	..	..	..	..	HS	S	S	S	SH	LH	R	H	..	L	..	..	L	..	..	..	L	..	L	..	..	..	..	L			
Drassidae																																			
Drassidae immature		..	..	L	..	..	..	..	..	..	..	..	G	..	..	..	..	..	..	..	..	..	L													
Sergiolus variegatus Hentz		..	..	..	..	..	..	..	..	..	..	..	..	..	..	R	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.L			
Theridiidae																																			
Theridion frondeum Hentz		..	..	..	..	..	H																													
Steatoda borealis Hentz		..	..	..	..	..	..	..	..	..	..	..	I																							
Euriopis funebris Hentz		..	..	..	..	..	..	..	..	..	..	..	..	..	..	R																				
Thomisidae																																			
Xysticus, *immature*		L	H	..	..	L	H	..	..	H	H	L	..	H	L	S	SL	..	L	L	L	L	L	H	..	L	..	L	L	..	..	..	L	..	L	L
X. elegans Keys.		..	G	..	..	..	..	H	H	..	..	..	..	..	..	..	.H																			
Philodromus *j.*		..	..	..	..	..	S	..	..	H	..	..	H	..	L																					
Misumena asperata Hentz		..	..	..	..	..	..	..	..	H	..	H																								
Coriarachne versicolor Keys.		..	..	..	..	..	..	..	..	..	..	..	S																							
Ebo latithorax Keys.		..	..	..	..	..	..	..	..	..	..	..	..	..	..	R																				
Oxyptila conspurcata Thor.		..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	L	L																
Tmarus caudatus Hentz		..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	S																	
Uloboridae																																			
Uloborus americanus Walck.		..	..	..	..	..	..	..	..	..	..	HL	..	..	..	..	..	S																		
Uloborus *immature*		..	..	..	..	..	..	..	..	..	..	L	H	..	..	..	..	H																		
Hyptiotes cavatus Hentz		..	..	..	..	..	..	..	..	..	..	H	..	..	..	..	..	S																		
Hyptiotes *immature*		..	..	..	..	..	..	..	..	..	..	..	S	..	..	..	..	S	..	..	..	..	..	..	..	..	..	..	H	..	..	..H.				

Table XXVII

Species.	Week No.--	July 4	July 11	July 18	July 25	Aug. 1	Aug. 8	Aug. 15	Aug. 22	Aug. 29	Sept. 5	Sept. 12	Sept. 19	Sept. 26	Oct. 3	Oct. 10	Oct. 17	Oct. 24	Oct. 31	Nov. 7	Nov. 14	Nov. 21	Nov. 28	Dec. 5	Dec. 12	Dec. 19	Dec. 26	Jan. 2	Jan. 9	Jan. 16	Jan. 23	Jan. 30	Feb. 6	Feb. 13	Feb. 20	Feb. 27	Mar. 6
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Insecta																																				
Coleoptera																																			
Chrysomelidae																																			
Glyptina spuria Lec.		..	..	..	..	..	..	..	..	..	..	S	..	S	..	..	..	..	S	L	..	H	..	L	L	..	..	..	L	..	..	..	..	..	..	L
Epitrix brevis Schw.		..	..	..	..	..	..	..	..	..	..	H	SH	H	..	H	..	..	..	..	..	..	..	..	..	..	..	..	..	L	L					
E. fuscula Crot.		..	..	..	..	..	..	..	..	..	..	L	..	L	..	..	..	L	L	L	L	L	..	..	L	L	..	..	L	..	..	..	..	..	..	L
Glyptina sp?		..	..	..	..	..	..	..	..	..	..	..	S	..	..	H																			
Chaetocnema confinis Crot.		..	..	..	..	..	..	..	..	..	..	S	S	..	..	S	..	..	..	L															
Phyllotreta sinuata Steph.		..	..	LG	..	..	..	..	..	..	..	..	..	..	L	..	L	..	L	L	..	..	L	..	..	..	..	L	L	..	..	..	L			
Longitarsus melanurus Melsh.		..	..	..	..	..	..	..	..	..	..	..	H	H	..	..	..	..	..	..	..	..	H													
Lema trilineata Oliv.		..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	L	..	..	..	..	..	..	..	..	L								
Cassida bivittata Say		..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	L	..	..	..	..	..	..	..	..	..	L							
Cerotoma trifurcata Forst.		..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	L																
Oedionychis gibbitarsa Say		..	..	..	..	..	..	..	..	..	..	..	..	..	..	R	..																			
Chalepus nervosa Panz.		H	..	..	..	..	..	H	H	H	H	S	..	H																						
Diabrotica vittata Fabr.		..	..	..	..	..	..	..	..	H	..	L	..	SH	HL	R	SH	..	L																	
Chelymorpha argus Herbst		..	H	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	L							
Lina interrupta Fabr.		..	..	L	..	..	..	..	..	..	..	..	..	..	..	..	L	..	..	..	..	L	..	L	L	L	..	..	..	L						
Diabrotica 12-punctata Fabr.		..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	H													
Metriona bicolor Fabr.		..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	L	..	L	L			
Cryptophagidae																																			
Tomarus pulchellus Lec.		..	..	..	..	..	..	..	..	..	..	S	..	..	..	..	..	..	..	L	..	..	..	..	..	..	..	..	L	..	..	..	..	..	L	
Anthicidae																																			
Notoxus monodon Fab.		..	..	..	..	..	..	..	..	H	..	L	HL	H	H	R	HR	..	LH	L	..	L	L	L	L	L	..	L	..	..	..	..	L	..	L	L
Carabidae																																			
Casnonia pennsylvanica L.		..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	L	L	L	..	..	L	..	..	L	..	L							
Lebia ornata Say		..	..	..	..	..	..	..	..	..	..	S	..	..	..	..	..	..	L																	
L. scapularis Dej.		..	..	..	..	..	..	..	..	..	..	..	L	S	H																					
L. atriventris Say		..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	L																
Pachys nubifer Csy. ?		..	..	..	..	..	..	..	..	..	..	..	..	..	L																					
Platynus 8-punctatus Fab.		..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	L	..	L	..	..	..	..	..	..	..	..	..	..	L						
Clivina bipustulata Fab.		..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	G																	
Agonoderus pallipes Fab.		..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	L																	

Table XXVIII

Species \ Date -- Week --	July 4 1	July 11 2	July 18 3	July 25 4	Aug. 1 5	Aug. 8 6	Aug. 15 7	Aug. 22 8	Aug. 29 9	Sept. 5 10	Sept. 12 11	Sept. 19 12	Sept. 26 13	Oct. 3 14	Oct. 10 15	Oct. 17 16	Oct. 24 17	Oct. 31 18	Nov. 7 19	Nov. 14 20	Nov. 21 21	Nov. 28 22	Dec. 5 23	Dec. 12 24	Dec. 19 25	Dec. 26 26	Jan. 2 27	Jan. 9 28	Jan. 16 29	Jan. 23 30	Jan. 30 31	Feb. 6 32	Feb. 13 33	Feb. 20 34	Feb. 27 35	Mar. 6 36
Coleoptera -- continued																																			
Carabidae -- concluded																																			
Dicaelus purpuratus Bon.	..	..	..	..	..	G																													
D. furvus Dej.	..	..	..	..	..	G																													
Anisodactylus carbonarius Say	..	..	..	..	..	..	..	..	..	..	..	G																							
A. interstitialis Say	..	..	..	..	L	..	..	..	..	..	..	L																							
A. baltimorensis Say	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	G																	
Harpalus erythropus Dej.	..	..	..	G	..	..	..	..	G																										
Harpalus sp?	..	..	..	..	..	..	..	..	G																										
Histeridae																																			
Hister vernus Say ?	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	L																	
Cerambycidae																																			
Parandra brunnea Fab.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	L												
Liopus fascicularis Harr.	..	..	..	..	..	H																													
Phalacridae																																			
Phalacrus politus Melsh.	..	..	..	..	..	..	..	..	..	..	..	..	H	HL	R	SHL	..	SL	HL	L	LH	L	L	L	L	..	L	L	L	..	L	L	.		
Other Phalacridae	..	..	..	..	..	..	..	..	..	..	..	..	S	H	R	SH	..	L	L	L	..	..	..	..	..	..	L								
Cucujidae																																			
Telephanus velox Hald.	..	..	..	..	..	..	..	..	..	..	..	..	..	H	..	..	..	L	L	L	L	L	..	..	L	..	..	L	..	..	L	L	..	L	
Silvanus surinamensis L- ?	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	L															
Pselaphidae																																			
Pilopius piceus Lec.	L	L	..	..	..	..	..	..	L	..	L																								
Nitidulidae																																			
Stelidota 8-maculata Say	L																																		
Epurea rufa Reit.	..	L	..	..	..	..	..	L	..	..	..	LG	..	L	..	..	..	L	..	L	L	..	..	..	..	..	L								
Brachypterus urticae Fab.	..	..	..	..	..	..	..	..	..	..	H																								
Coccinellidae																																			
Chilocorus bivulnerus Muls	..	..	..	..	..	..	..	..	..	..	..	..	..	H																					
Megilla maculata DeGeer	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	H														
Hyperaspis undulata Say	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	L																
Anobiidae																																			
Caenocara bicolor Germ.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	S	..	..	..	L															

Table XXIX

Date --	July 4	July 11	July 18	July 25	Aug. 1	Aug. 8	Aug. 15	Aug. 22	Aug. 29	Sept. 5	Sept. 12	Sept. 19	Sept. 26	Oct. 3	Oct. 10	Oct. 17	Oct. 24	Oct. 31	Nov. 7	Nov. 14	Nov. 21	Nov. 28	Dec. 5	Dec. 12	Dec. 19	Dec. 26	Jan. 2	Jan. 9	Jan. 16	Jan. 23	Jan. 30	Feb. 6	Feb. 13	Feb. 20	Feb. 27	Mar. 6
Week No. --	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Coleoptera --concluded																																				
Elateridae																																				
Ludius attenuatus Say	H	..	H																																	
Asaphes memnonius Hbst.	..	..	..	L																																
Glyphonyx testaceus Melsh.	..	..	..	..	..	..	..	..	..	..	..	L	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	L	L	..	..	..	..	..	L	
Drasterius sp?	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	L	L	..	..	..	..	..	..	..	..	L	L							
Lampyridae																																				
Photinus pyralis L.	H																																			
P. scintillans Say	L																																			
Lycidae																																				
Plateros canaliculus Say	..	H																																		
Staphylinidae																																				
Staphylinus viridanus Horn	L																																			
Lathrobium simplex Lec.?	G	G																																		
L. longiusculum Grav.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	L	..	..	..	..	L													
Tachyporus jocosus Say	..	..	..	G	L																															
Stilicus dentatus Say	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	L																	
Aleocharinae	..	H	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	L	..	..	..	..	..	..	L	L	..	..	L				
Lathrididae	..	..	..	..	..	..	..	..	..	..	G	..	..	H	..	..	..	..	L	L	..	..	..	L	..	..	..	..	..	..	..	H				
Dytiscidae																																				
Copelatus glyphicus Say	..	..	L																																	
Curculionidae																																				
Phytonomus nigrirostris Fab.	L	H	HL	..	..	..	..	H	L	..	L	L	H	L	..	..	..	L	..	..	..	..	..	L	L	..	..	L	..	L	..	..	..	L		
Hypera punctata Fab.	..	..	..	..	..	..	..	..	H	..	S	..	..	..	..	..	..	L																		
Gelus oculatus Say	..	..	..	..	..	..	..	..	S	..	..	..	..	..	..	H																				
Conotrachelus tuberosus Lec.	H																																			
C. seniculus Lec.	..	..	..	..	..	..	..	..	..	..	..	..	..	L																						
Apion sp?	..	..	..	..	..	..	..	..	..	..	..	..	H	H	H	S																				
Other curculionidae	..	..	..	..	..	..	..	H	..	..	..	..	..	..	..	..	..	L	..	..	L															
Corrodentia																																				
Psocidae																																				
Psocus minusculus Bks.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	H																					
Caecilius aurantiacus Hagen	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	H																				

Table XXX

Species.	Week No. --	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
	Date --	July 4	July 11	July 18	July 25	AUG. 1	Aug. 8	Aug. 15	Aug. 22	Aug. 29	SEPT. 5	Sept. 12	Sept. 19	Sept. 26	OCT. 3	Oct. 10	Oct. 17	Oct. 24	Oct. 31	NOV. 7	Nov. 14	Nov. 21	Nov. 28	DEC. 5	Dec. 12	Dec. 19	Dec. 26	JAN. 2	Jan. 9	Jan. 16	Jan. 23	Jan. 30	FEB. 6	Feb. 13	Feb. 20	Feb. 27	MAR. 6
Hymenoptera																																					
Formicidae																																					
Formica fusca L.		H	..	..	..	..	G	..	..	H																											
Camponotus herculeanus pennsylvanicus DeGeer		..	H	..	..	..	G																														
Lasius niger americanus Emery	L	..	..	G	..	..	..	..	..	G																											
Ponera coarctata pennsylvanica (Buckley) Emery		..	L	..	..	..	L	..	L																												
Aphaenogaster fulva Rog.		..	..	..	..	..	L	..	..	..	..	..	..	G																							
Camponotus caryae Fitch var?		..	..	..	..	..	..	..	H	H	..	H	H	..	H																						
Prenolepis imparis Say		..	..	..	..	..	..	..	..	..	..	H																									
Crematogaster lineolata Say		..	..	..	..	..	..	..	..	..	..	..	..	H																							
Lasius umbratus mixtus Nyl. var. aphidicola Walsh		..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	G														
Myrmica punctiventris Rog.		..	H	..	H	..	H	..	H	H	..	S	S	..	H																						
M. scabrinodes schencki Emery var. emeryana Forel		..	..	H	H	..	H	..	H	H	..	H	..	H	H	..	..	..	..	..	..	G															
Hemiptera																																					
Cicadellidae																																					
Scaphoideus auronitens Prov.		H	..	..	..	..	HS																														
Phlepsius irroratus Say		..	..	..	..	..	..	..	..	S																											
Gypona 8-lineata (Say) *nymph*		..	..	..	H																																
Deltocephalus inimicus Say		..	..	..	..	..	..	..	..	H	..	S	..	S																							
Empoasca viridescens Walsh		..	..	..	..	..	..	..	..	..	..	..	H	SH	H	..	SH	..	SH	H	L	L	SH	H	..	L	..	..	..	..	L	L	..	..	..	..	L
Erythroneura tricincta catycula McAtee		..	..	..	..	..	..	..	..	..	..	..	..	S																							
E. Obliqua Say		..	..	..	..	..	..	..	..	..	..	..	..	S					L	L	..	..	S	..	L	..	..	L	L	..	L	L	L	..	L	L	L
E. obliqua parma McAtee		..	..	..	..	..	..	..	..	..	..	..	..	..	H	..	..	..	..	..	..	..	..	L													
E. obliqua noevus Gill.		..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	L																	
E. comes vitis Harr.		..	..	..	..	..	..	..	..	..	..	..	..	H	..	..	S	..	..	..	..	..	S													
Balclutha punctata Fhmb.		..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	L														
Thamnotettix longulus Gill. & Baker.		..	..	..	..	..	..	..	..	..	..	..	H	..	..	..	..	..	..	..	..	L														
Dikraneura carnecla (Stål.)		..	..	..	..	..	..	..	..	..	..	..	..	..	H							S														
Graphocephala versuta (Say)		..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..														

Table XXXI

Date --	July 4	July 11	July 18	July 25	Aug. 1	Aug. 8	Aug. 15	Aug. 22	Aug. 29	Sept. 5	Sept. 12	Sept. 19	Sept. 26	Oct. 3	Oct. 10	Oct. 17	Oct. 24	Oct. 31	Nov. 7	Nov. 14	Nov. 21	Nov. 28	Dec. 5	Dec. 12	Dec. 19	Dec. 26	Jan. 2	Jan. 9	Jan. 16	Jan. 23	Jan. 30	Feb. 6	Feb. 13	Feb. 20	Feb. 27	Mar. 6
Week No. --	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Diptera																																				
Mycetophilidae																																				
Sciara sp? *undescribed*	..	..	..	..	..	..	..	..	H	..	..	S	SR	..	R	..	..	L	L																	
Sciara sp? *larvae*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	GL	..	..	..	..	G	..	..	L				
Sceptonia nigra Meig.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	S	L	..	..	..	..	..	..	L										
Mycetophila punctata Meig	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	L	..	L	..	..	..	L	..	..	..	..	L						
Exechia sp?	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	H															
Cordyla volucris Joh.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	H															
Allodia falcata Joh.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	G														
Chironomidae																																				
Chironomus sp? *undescribed*	..	..	H	..	..	..	..	..	..	..	..	..	H																							
Forcipomyia specularis Coq.	..	..	..	..	..	..	..	..	..	..	..	..	S																							
Atrichopogon sp? *undescribed*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	L															
Camptocladius sp? *larva*	..	..	..	..	L																															
Drosophilidae																																				
Leucophenga varia Walk.	..	..	..	..	..	..	..	..	..	..	..	..	..	H																						
Drosophila quinaria Loew.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	S																		
Tachinidae																																				
Microphthalmia disjuncta Wied.	..	..	..	..	..	..	..	H																												
Sciasma nebulosa Coq.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	H																				
Emphanopteryx sp? *pupa*	..	..	..	..	..	..	..	..	H																											
Scatophagidae																																				
Scatophaga stercoraria L.	..	..	..	..	..	..	..	H																												
Anthomyidae																																				
Phorbia fusciceps Zett.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	H														
Dexiidae																																				
Dexia vertebrata Say	..	H																																		
Sepsidae																																				
Sepsis violacea Meig.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	H														
Phoridae																																				
Aplochaeta sublutea Mall.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	L																	
Platypezidae																																				
Platypeza velutina Loew.	..	..	..	..	..	..	..	..	..	..	..	..	..	H																						

Table XXXII

Species.	Date -- Week No.--	July 4 1	July 11 2	July 18 3	July 25 4	Aug. 1 5	Aug. 8 6	Aug. 15 7	Aug. 22 8	Aug. 29 9	Sept. 5 10	Sept. 12 11	Sept. 19 12	Sept. 26 13	Oct. 3 14	Oct. 10 15	Oct. 17 16	Oct. 24 17	Oct. 31 18	Nov. 7 19	Nov. 14 20	Nov. 21 21	Nov. 28 22	Dec. 5 23	Dec. 12 24	Dec. 19 25	Dec. 26 26	Jan. 2 27	Jan. 9 28	Jan. 16 29	Jan. 23 30	Jan. 30 31	Feb. 6 32	Feb. 13 33	Feb. 20 34	Feb. 27 35	Mar. 6 36
Diptera -- continued																																			
Muscidae																																			
Orthellia caesarion Meig.		..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	S	..	..	L	..	..	..	..	..	..	L	L					
Oscinidae																																			
Batanobia pusilla Meig. ?		..	..	..	..	..	..	..	..	..	..	..	..	..	H																				
Chloropisca glabra Meig.		..	..	..	..	..	..	..	..	..	..	..	..	..	H																				
Hippelastes flavipes Loew		..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	H																		
Borboridae																																			
Leptocera evanescens Tucker		..	..	..	..	..	..	..	..	..	..	..	..	..	H	..	..	..	..	L	L	..	LH	L	L	H	..	..	..	..	..	..	L	..	L	
Dolichopodidae																																			
Dolichopus funditor Loew		H			•																														
Psilopus patibulatus Say		..	..	H	..	..	..	..	S																										
P. scintillans Loew		..	..	..	H	..	SH	..	H	..	H																								
Pelastoneurus vagans Loew		..	..	..	..	..	..	..	..	..	..	..	..	..	H																				
Sympycnus lineatus Loew		..	..	..	..	..	..	..	..	..	..	..	..	H	H																				
Sapromyzidae																																			
Sapromyza fraterna Loew		H	..	H	H	..	H																												
Minettia lupulina Fab.		..	..	..	..	..	H																												
Tipulidae																																			
Cladura flavoferruginea O.S.		..	..	..	..	..	..	..	..	..	..	..	..	..	H	..	H																		
Dicranoptycha sobrina O.S.		..	..	..	..	..	..	..	H																										
D. winnemana Alex.		..	..	S																															
Tipula unimaculata Liv.		..	..	..	..	..	H																												
Tipula sp? *larvae*		G	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..																		
	pupa																																		
Helobia hybrida Meig.		..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	H	..	..	..	..	..	H												
Rhipidia domestica O.S.		..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	H																		
Trichocera brumalis Fitch		..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	H	H	..	L													
Chionea sp?		..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	L														
Therevidae																																			
Psilocephala *larva*		..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	L			
Leptidae																																			
Chrysopila sp? *larvae*		..	..	L	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	G												

Table XXXIII

Date --

Species. Week No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Diptera -- continued																																				
Agromyzidae																																				
Agromyza sp? *larvae*	..	..	..	..	..	..	..	..	H	..	..	..	..	..	..	..	..	..	..	L																
Stratiomyidae																																				
Geosarpis viridis ? *larvae*	..	G	G	..	..	..	..	..	..	..	..	L	..	L																						
Microchrysa sp? *larvae*	..	L																																		
Genus incertus 3 Malloch	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	L																		
Bibionidae																																				
Bibio albipennis Say ?	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	L	..	..	G	..	..	..	L											
Hemiptera																																				
Fulgoridae																																				
Acanalonia conica Say	H	H																																		
" " *nymphs*	H	H																																		
Ormenis pruinosa Say	..	H	H																																	
O. septentrionalis Spin.	..	..	SH.	..	..	..	..	..	SH	..	..	..	..	..	..	..	..	..	..	..	..	H														
" " *nymph*	..	H																																		

Plate I. Temperature Data

Weekly mean temperatures of air and soil at 10 M and 0.6 M. above the surface of the soil and 0.1 M. below the surface of the soil.

Temperatures are given in degrees, Centigrade, the base-line representing -10°, and the horizontal lines, respectively, -5°, 0°, 10°, 15°, and 20°. The top marginal line of the chart represents 25°. Each smaller interval indicated on the lateral margin represents 1°C.

Beginning with the left margin, the successive vertical lines represent five-week intervals, beginning with June 27. The subsequent vertical lines are drawn in the positions representing, respectively, the weeks ending August 1, September 5, October 10, November 14, December 19, January 23, and February 27. Each smaller interval indicated on the upper and lower margins represents one week.

A -- Temperature at Station A, 0.6 M. above ground surface

B -- Temperature at Station B, 10 M. above ground surface

C -- Soil temperature 0.1 M. below surface of ground.

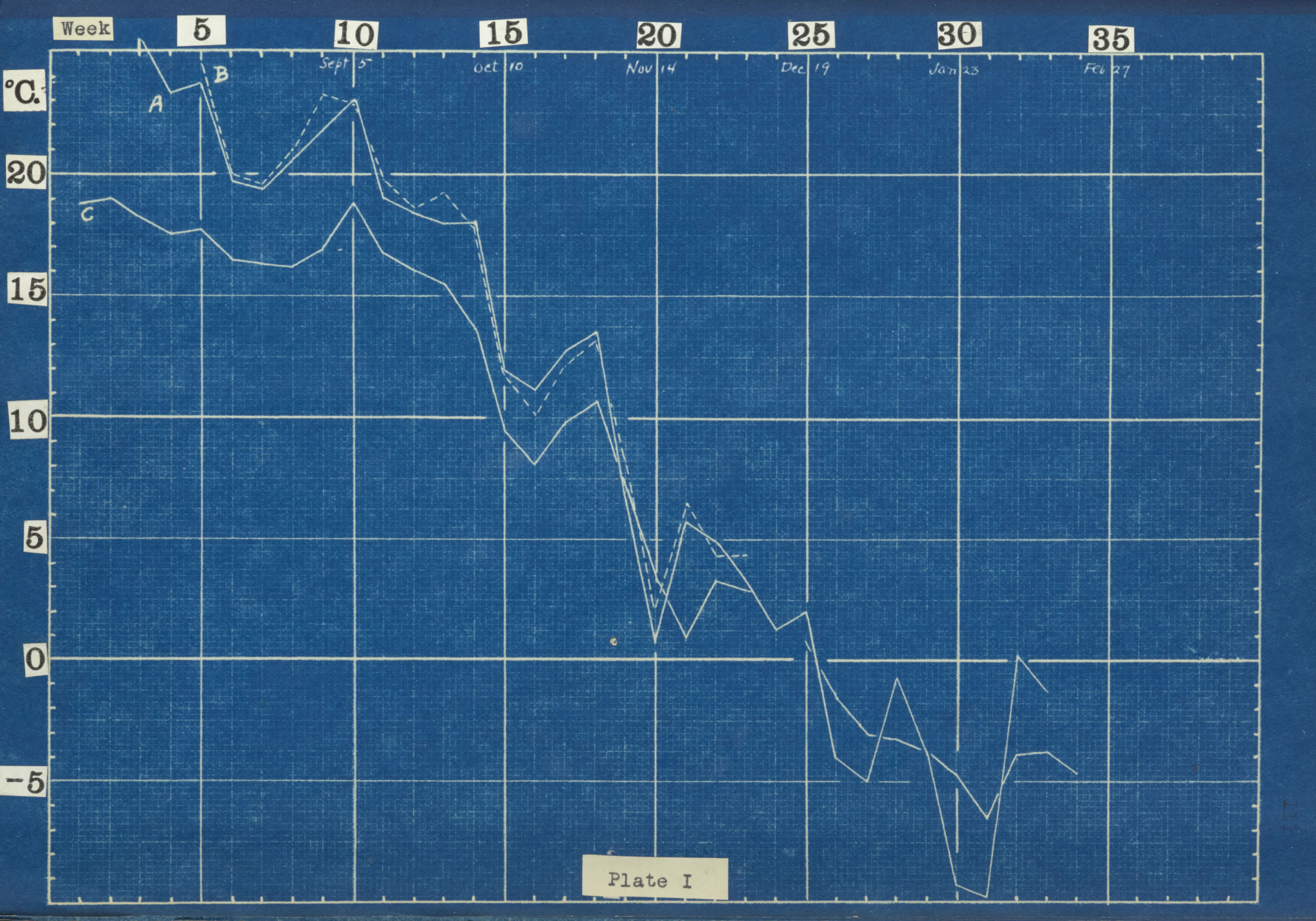

Week
5
10
15
20
25
30
35
°C.
20
15
10
5
0
−5
Sept 5
Oct 10
Nov 14
Dec 19
Jan 23
Feb 27
A
B
C

Plate I

Plate II. Temperature Data

Weekly mean variation in temperature of air and soil at 10 M. and 0.6 M. above the surface of the soil, and 0.1 M. below the surface of the soil.

Notation is the same as in Plate I. 0°C. is represented by the heavy line near the bottom of the plate, and the horizontal lines are at the levels representing 5°, 10°, and 15°C.

A -- Temperature variation at Station A

B -- Temperature variation at Station B

C -- Variation in soil temperature.

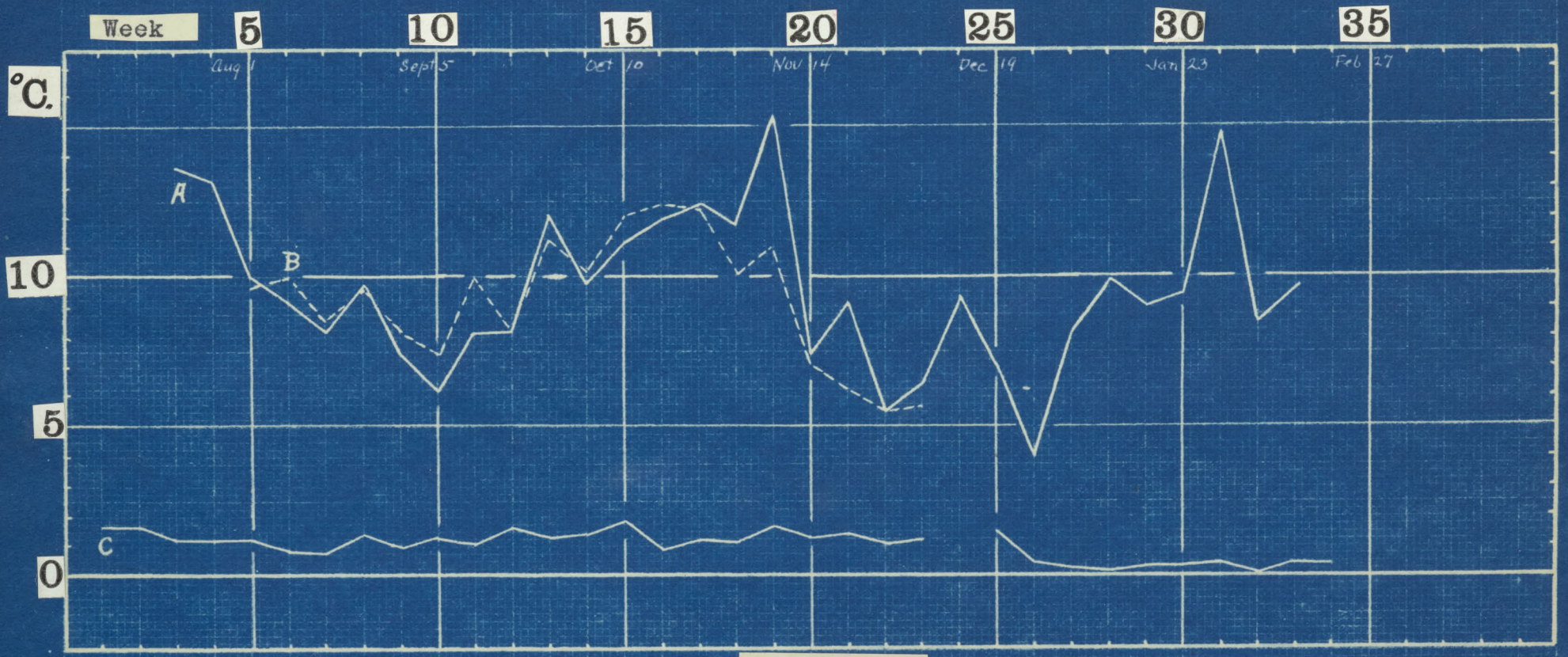

Week
5
10
15
20
25
30
35
Aug 1
Sept 5
Oct 10
Nov 14
Dec 19
Jan 23
Feb 27
°C.
10
5
0
A
B
C

Plate II

Plate III. Temperature Data

Thermograph records for the week ending September 12, for Station A, 0.6 M. above the surface of the ground and Station B, 10 M. above the surface of the ground.

A -- Thermograph record from Station A

B -- Thermograph record from Station B

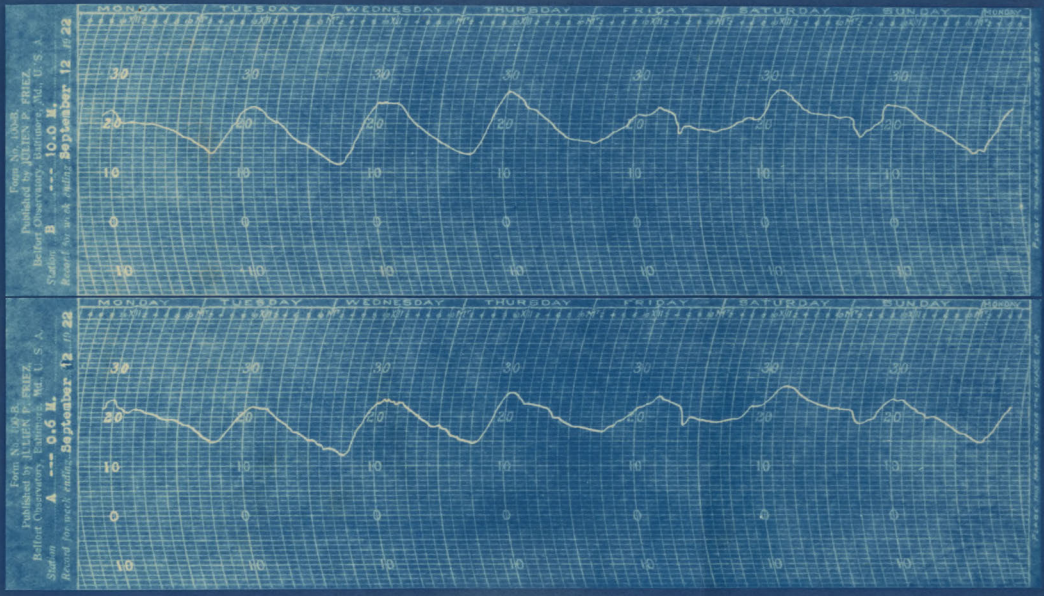

MONDAY
TUESDAY
WEDNESDAY
THURSDAY
FRIDAY
SATURDAY
SUNDAY
Form No. 1008.
Published by JULIEN P. FRIEZ.
Belfort Observatory, Baltimore, Md., U. S. A.
Station B --- 10.0 M.
Record for week ending September 12 th 22
Station A --- 0.6 M.
Record for week ending September 12 th 22

Plate III

Plate IV. Temperature and Relative Humidity Data

Mean Temperature and Mean Relative Humidity of an average day, as computed from the two-hour means for the week ending September 12. (The thermograph records from which this calculation was made are illustrated in Plate III. The hygrograph records are not illustrated)

The space between horizontal lines represents 1°C., beginning at the bottom of the chart with 14°, and 2% Relative Humidity, beginning at the bottom of the chart with 70%.

Each vertical line represents one two-hour period, beginning at the left with 6:00-8:00 A.M., and ending at the left with the same.

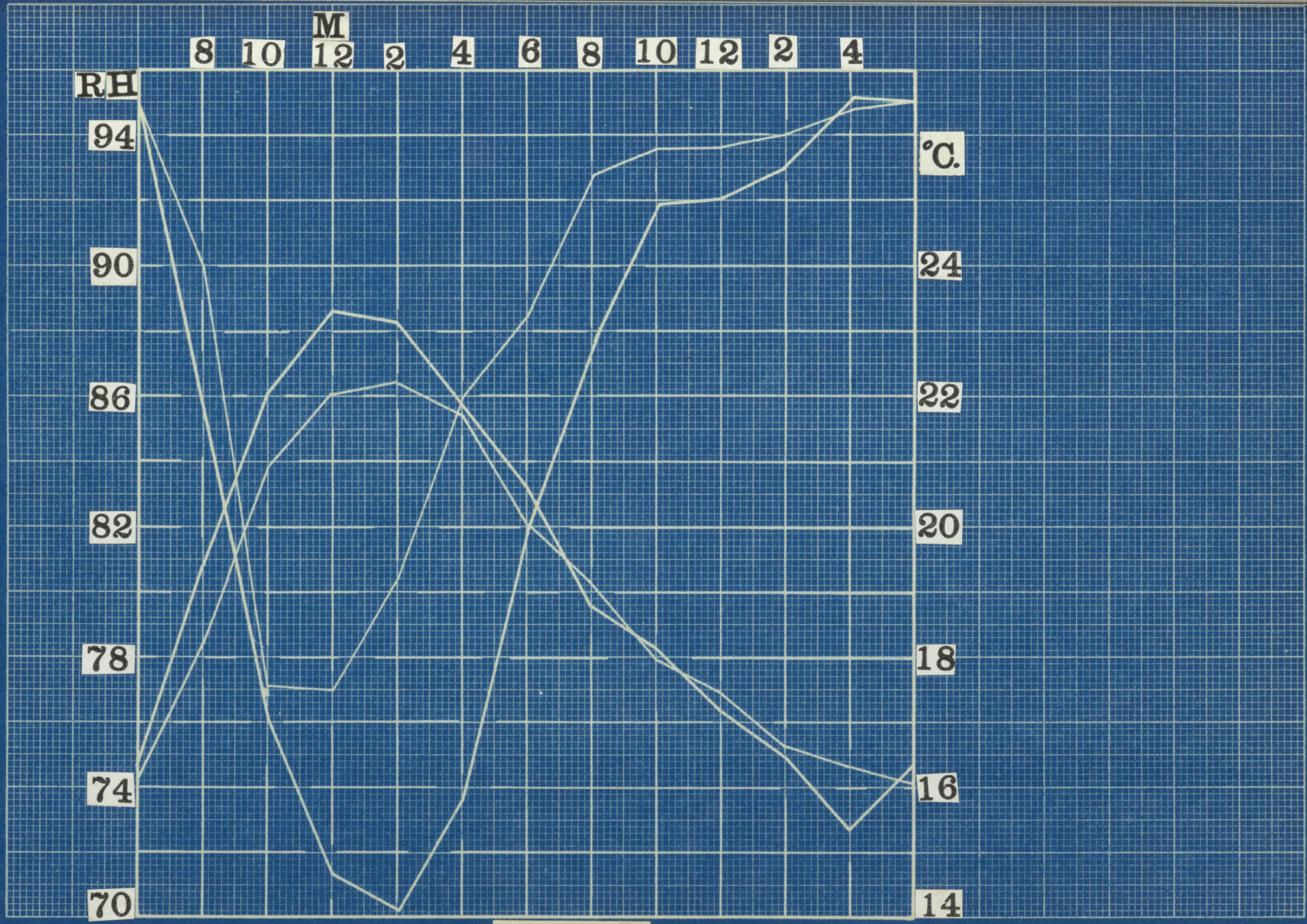


Plate IV

Plate V. Humidity Data

Weekly Mean Relative Humidity, and Weekly Mean Variation in Relative Humidity at Stations A and B, and Weekly Mean Absolute Humidity at Station A.

Vertical divisions represent 5-week intervals as in Plates I and II. Horizontal divisions represent 10% relative Humidity, and 2.0 mm. Partial Pressure of Hg. Absolute Humidity. For Graphs A and B, the top margin of the plate represents 100% relative humidity, and each successive horizontal line below, 10% less.

For Graphs A' and B', the bottom margin of the plate represents 10% variation and each successive horizontal line 10% additional. For Graph C, the heavy horizontal line represents 0.0 mm. Hg. partial pressure, and each successive horizontal line above, 2 mm. additional.

A -- Relative Humidity at Station A

B -- Relative Humidity at Station B

A' - Variation in Relative Humidity at Station A

B' - Variation in Relative Humidity at Station B

C -- Absolute Humidity (in Millimeters of Mercury Partial Pressure) at Station A

UNIVERSITY OF ILLINOIS

GRADUATE SCHOOL

Instructions for the Preparation of Masters' and Doctors' Theses

1. SUBJECT. A thesis subject must be approved by the Head of the Department in which it is written. Arrangements for theses must be made in sufficient time for the Head of the Department to report a list of approved thesis subjects to the Dean by the first Monday in November.

2. TIME OF COMPLETION. *Doctors'* theses must be completed and a typewritten copy in the hands of the Dean by noon of the Saturday nearest the middle of May; *masters'* theses must be completed and a typewritten copy in the hands of the Dean by noon of the first Saturday in June. The instructor in charge may require the thesis as much earlier as he deems necessary. Before the final copy of the thesis is made the student should submit to the instructor in charge a complete draft, which, in all particulars except typographical form, should be as nearly as possible like the finished copy; and the final typographical form should be fully indicated.

Each candidate for a *professional engineering degree* must file an outline of his thesis with the Chairman of the Committee on Advanced Engineering Degrees, on or before December 31st preceding the Commencement at which he proposes to qualify. The completed thesis must be filed with the Engineering Committee not later than April 1.

3. PAPER. In its final form, the thesis must be typewritten upon standard thesis paper, which consists of Crane's Japanese Linen, 17 in. x 22 in.,—24 lb., cut to 8½ in. x 11 in., and ruled as follows: Plain, with double-ruled red border, with one-half inch margin on top, right-hand side and bottom, and one inch margin on the left-hand side, making plate 7 in. x 10 in. inside of border.

Diagrams may be platted upon cross-ruled paper, but the sheets must be of the above size or larger; and if the sheet is larger than standard thesis paper, it must be folded to substantially that size.

4. ILLUSTRATIONS. The illustrations may consist of diagrams, drawings, and photographs (preferably bromide prints), or, if necessary, of blue prints or other forms of reproduction which meet the approval of the instructor in charge.

Drawings upon folded sheets may be inserted if necessary. If a folding sheet is employed, it should be of thin bond paper, and should be as small as is consistent with legibility; great care must be exercised in folding it, so that it may readily be unfolded after the thesis has been bound, and also so that it will not be cut when the thesis is trimmed by the binder.

must

5. COPYING THE THESIS. The thesis must be neatly typewritten. Indelible black ink or black record ribbon should be used. The wide margin of the paper must be at the left hand; and in no case should the writing be outside of the red-line border. The writing should begin near the left-hand border line, and this margin should be uniform. The right-hand margin should be as uniform as possible. The pages should be numbered at the center of the top or at the upper right-hand corner inside of border. Where there is any intention or necessity of printing the thesis later, as in the case of a doctor's thesis, a carbon copy should be made, as the copy deposited with the Dean for binding and preservation in the library cannot be withdrawn for the printer's use.

6. TITLE PAGE. The title page must be printed in accordance with the model shown below. The model gives both style and size

of typewritten theses

(1) ACOUSTICS OF AUDIENCE ROOMS

(2) BY

(3) WALTER FRANCIS SMITH

(4) B. S. University of Illinois, 1903.

---

(5) THESIS

(6) Submitted in Partial Fulfillment of the Requirements for the

(7) Degree of

(8) DOCTOR OF PHILOSOPHY

(9) IN PHYSICS

(10) IN

(11) THE GRADUATE SCHOOL

(12) OF THE

(13) UNIVERSITY OF ILLINOIS

(14) 1908

NOTE:—Lines 1, 4, 5, 6, 7, 8, 13, 14 are 12 point Antique type; lines 2, 10, 12 are 8 point; lines 3, 9, 11 are 10 point.

of type. Proofs of the title page should be submitted for the approval of the instructor in charge before being printed.

7. CERTIFICATE. The manuscript of the thesis must be accompanied with a certificate of approval. For masters' theses this approval must be given by the person under whose immediate supervision the thesis was prepared, and also by the Head of the Department. In the case of doctors' theses, the approval must be by the person under whose immediate supervision the thesis is prepared and the committee on final examination. This certificate is to be prepared by the member of the faculty in charge of the thesis, upon a blank obtained at the office of the Dean of the Graduate School.

8. TABLE OF CONTENTS. Each thesis must have a table of contents; the Roman numbers I, II, etc., should precede the titles of the subdivisions; the table of contents may be accompanied with a list of tables, figures, and plates with their serial numbers and the number of the page upon which each is found.

9. ARRANGEMENT. The usual make-up of a printed book should be followed in the opening pages. First should come the title page, followed immediately by the certificate; next should be placed the table of contents, entire. The headings for chapters or other main subdivisions, as indicated by the table of contents, should be inserted in their proper places throughout the thesis, just as chapter headings appear in a printed book. These should be preceded by the Roman numerals I, II, etc.

10. VITA. Each doctor's thesis must have an appendix giving a short biography of the candidate, including the institutions he has attended, his degrees and honors, the titles of his publications, teaching or professional experience, and such other matters as may be pertinent.

11. PUBLICATION. Both the results of the investigation and the completed thesis are the property of the University, and no portion of either may be published except by permission of the Dean of the Graduate School.

12. PRINTED THESES. Thesis manuscript in condition for the press, the publication of which has been provided for, may be accepted as fulfilling the thesis requirement for graduation upon the recommendation of the Head of the Department in which the work is done and assurance that printed copies will be filed with the Librarian of the University by a specified date.

13. PRINTING. The doctor's thesis must be printed and one hundred copies deposited in the Library of the University not later than the first of June preceding the conferring of the degree. If it is not printed by the first of June, the student must deposit seventy-five dollars ($75) or a bond for that amount satisfactory to the Comptroller of the University and the Dean of the Graduate School. If a bond is accepted, it must be replaced at the end of one year with a cash deposit. At the end of two years, if the thesis has not then been printed by the student, the University will print such part of it as it deems best.

Each printed thesis must have a title page, and this title page must give all details of information indicated in the model above. It is not sufficient to give this information on the cover.

The cash deposit made by the student who does not print his thesis by the end of the second year after his degree is conferred becomes the property of the University, to be used for the general purpose of printing theses, and all graduate students who receive their degrees must agree at the time when the deposit is made that the University shall become the owner of this deposit for this purpose. [In effect Sept. 1913.]

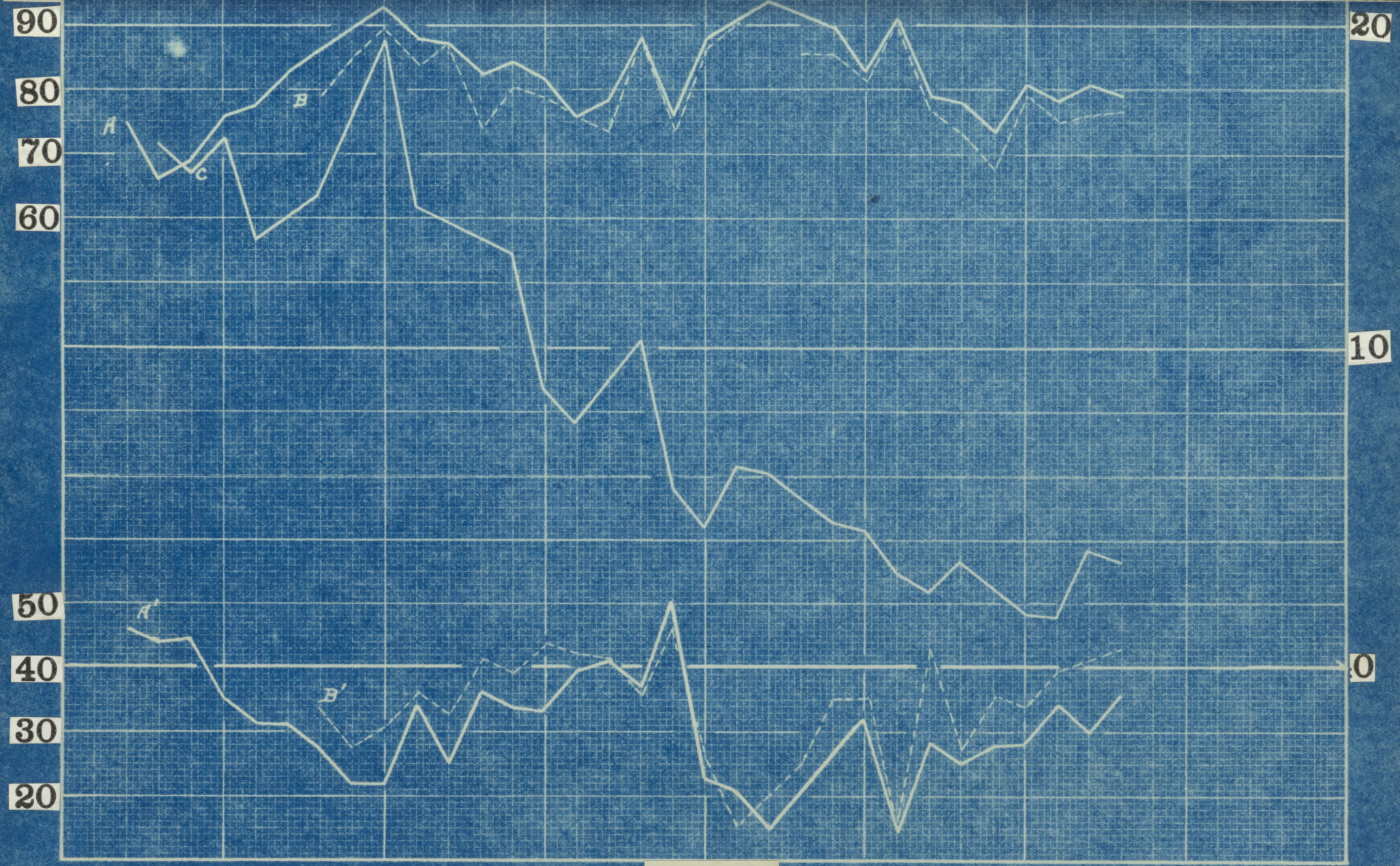


Plate V

Plate VI. Light Data

Relative intensity of light at a height of 1.25 M. in the forest and in an open glade. The vertical scale is between 0% and 100%, in terms of maximum light intensity observed in the glade (9929 Foot-Candles, at 12:30 P.M.). The vertical lines represent 6:00 A.M., 12:00 M. and 6:00 P.M. The smaller divisions indicated at top and bottom represent hours.

G -- Light intensity at 1.25 M. in the open glade

F -- Light intensity at 1.25 M in the forest.

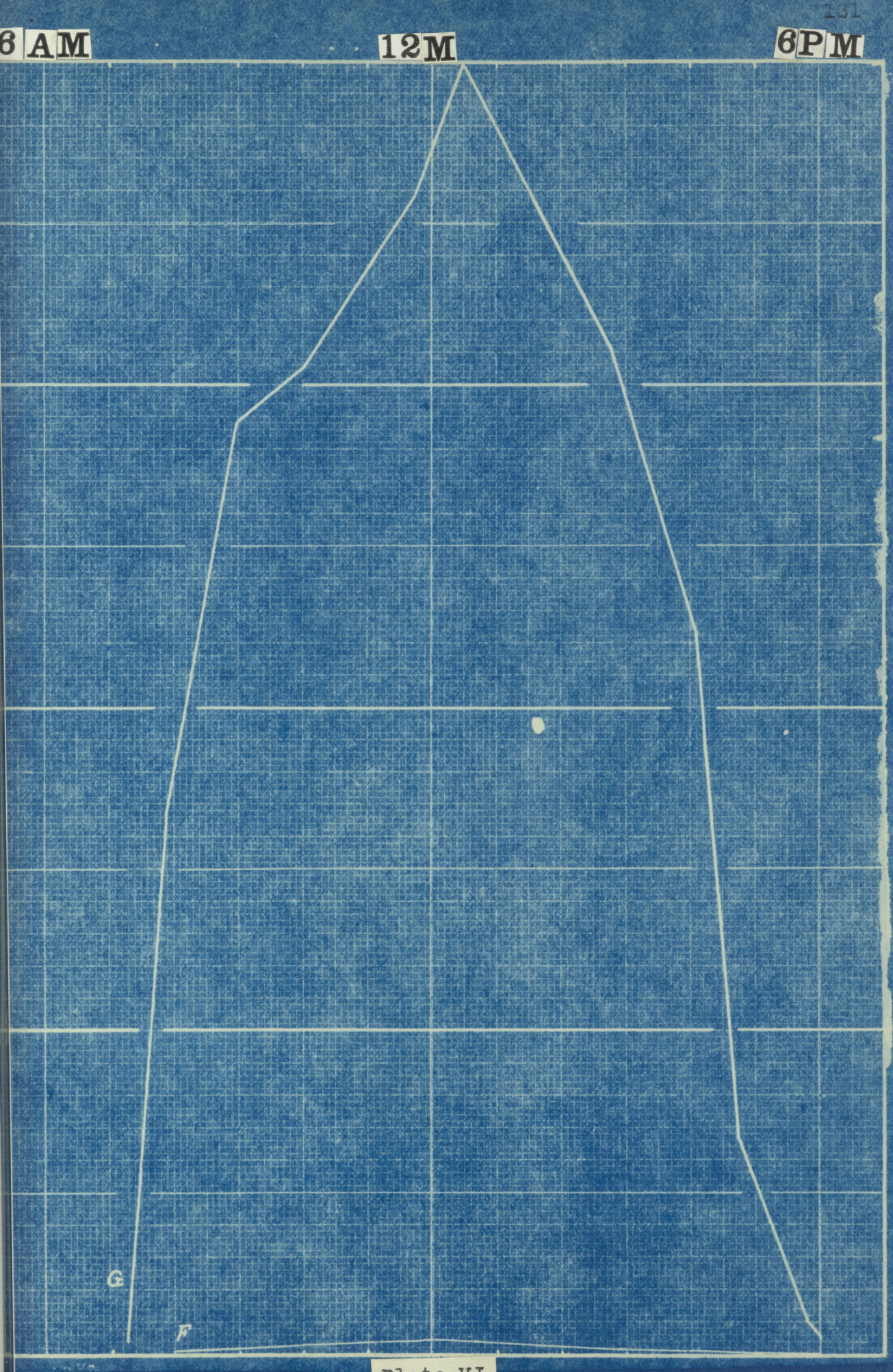


Plate VI

Plate VII. Light Data

Relative intensity of light at a neight of 1.25 M. in the forest and at ground level under herbage. The vertical scale is between 0% and 1%, in terms of maximum light intensity observed in the glade (See Plate VI), and each horizontal ruling represents an interval of 0.1%. The vertical lines represent 6:00 A.M., 12:00 M. and 6:00 P.M. The smaller divisions indicated at top and bottom represent hours.

F -- Light intensities at 1.25 M. in the forest

O -- Light intensity at ground level in the forest

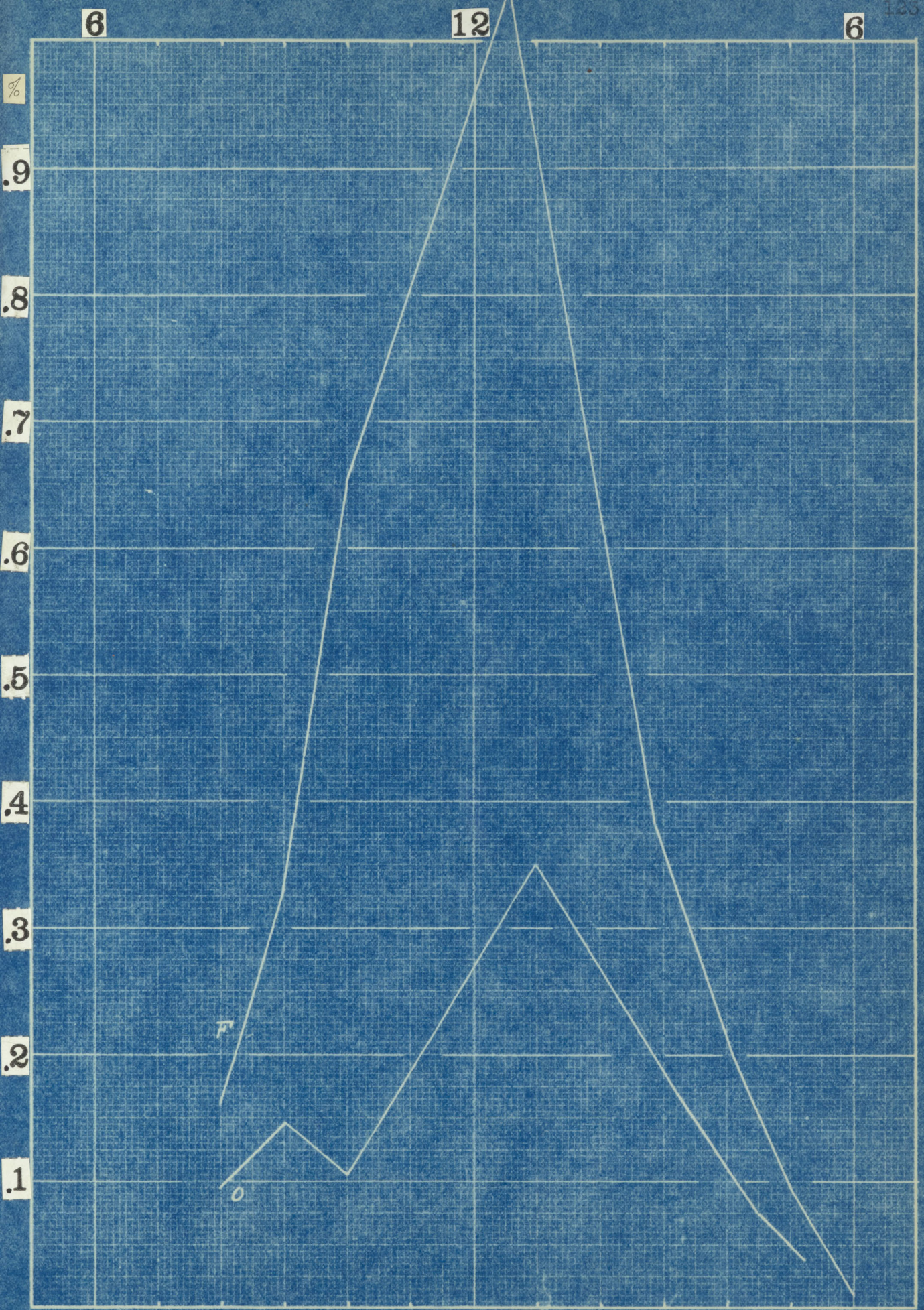


Plate VII

Plate VIII. Evaporation Data

Evaporation from Porous Cup Atmometers at Stations 1, 3, 5 and 9.

The vertical scale is between 4 cc. and 21 cc. mean daily evaporation, the horizontal lines being drawn at 5 cc., 10 cc., and 20 cc.

The vertical lines represent five-week periods, and the smaller divisions represent one-week periods.

The graphs are numbered according to the stations which they represent.

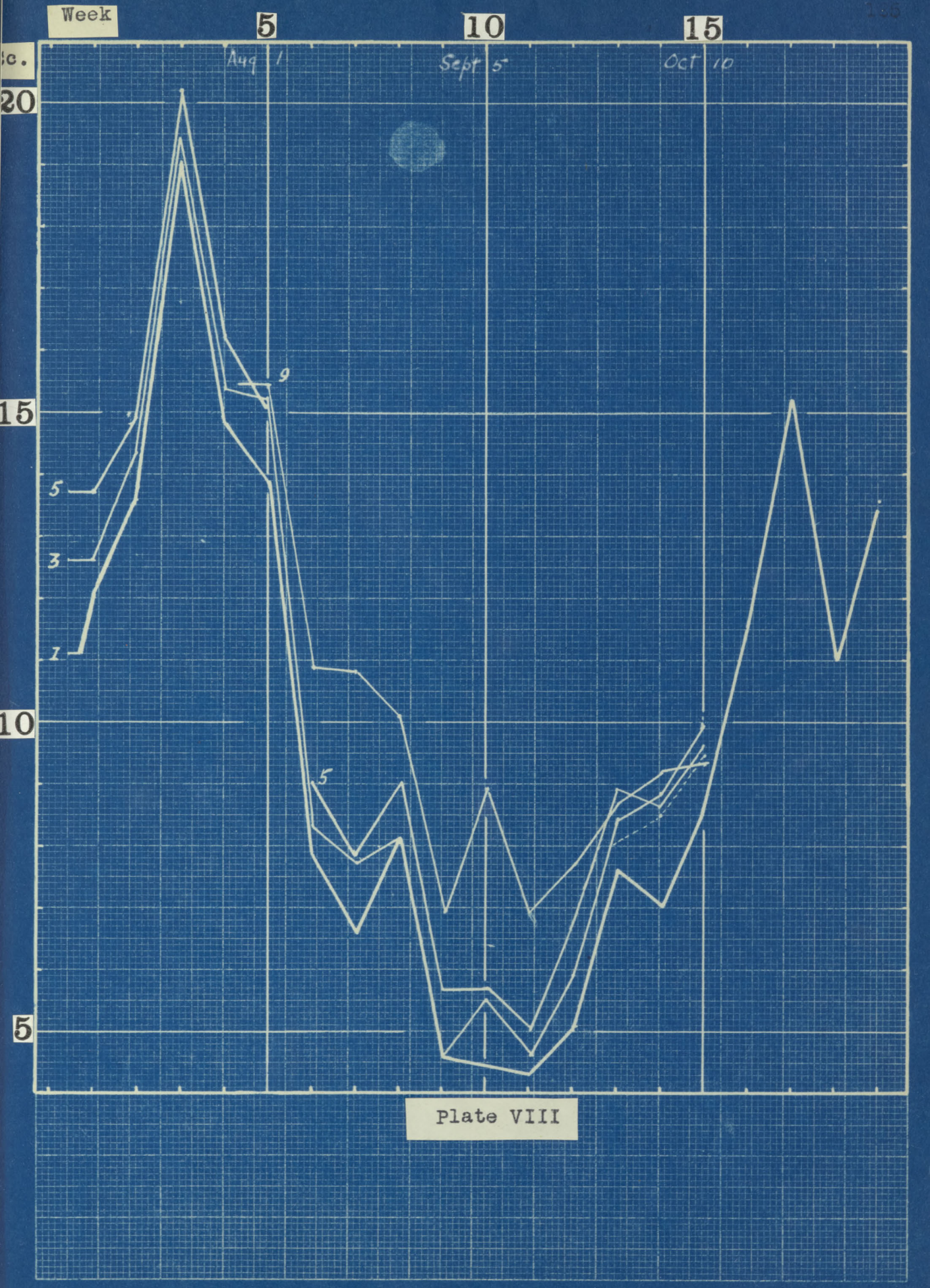


Plate VIII

VIII

Plate IX. Evaporation Data

Evaporation from Porous Cup Atmometers at Stations 1, 3, 6, 8 and 10.

The vertical scale is between 1 cc. and 20 cc. mean daily evaporation, with horizontal lines as in Plate VIII.

The graphs are numbered according to the stations they represent.

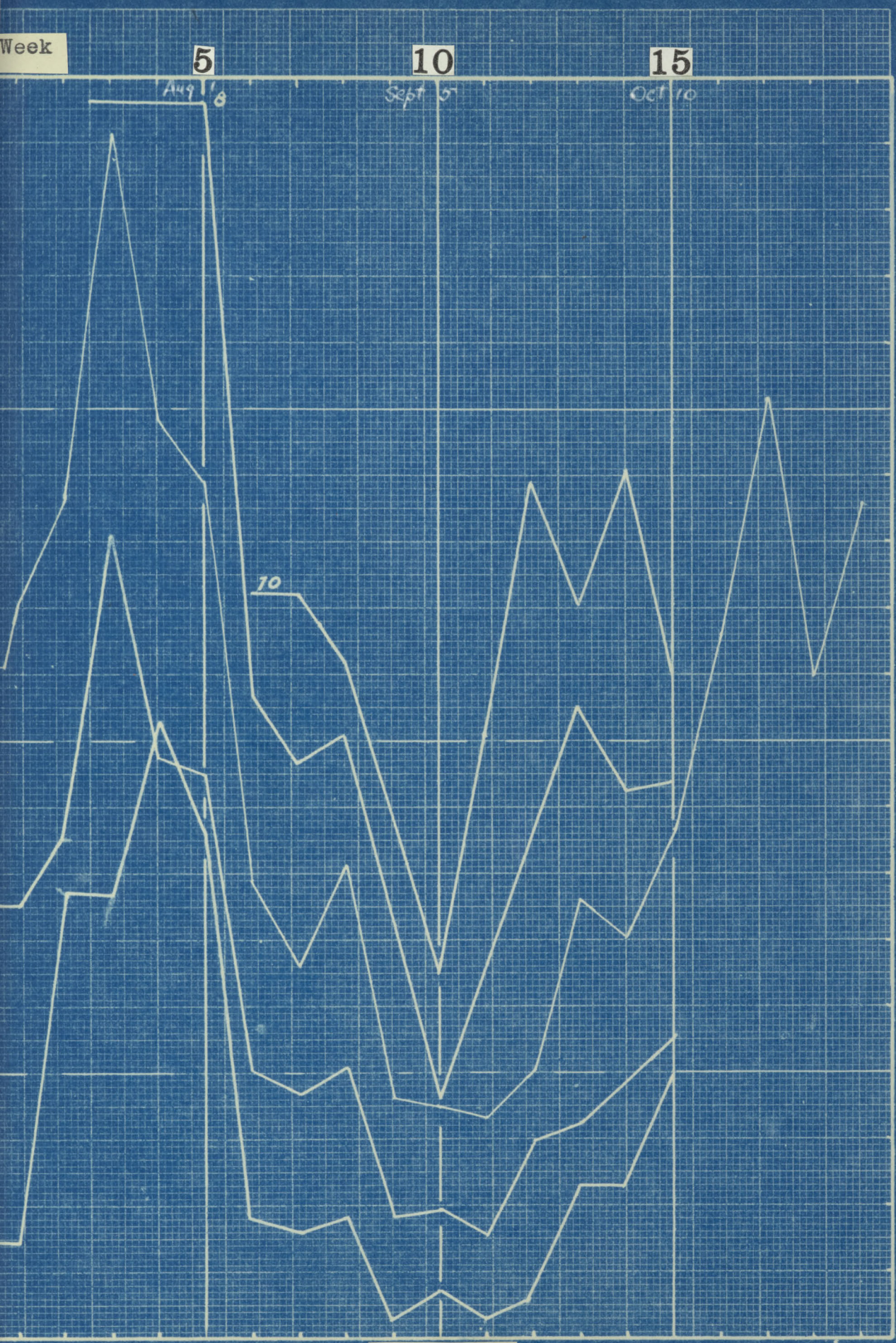


Plate IX

Plate X. Evaporation Data

Comparative Mean Daily Evaporation from Porous Cup Atmometers at Stations 1 to 11, for the Entire Season

The vertical scale is from 0 cc. to 17 cc. mean daily evaporation, each division representing 1 cc. Each rectangle is numbered according to the station represented.

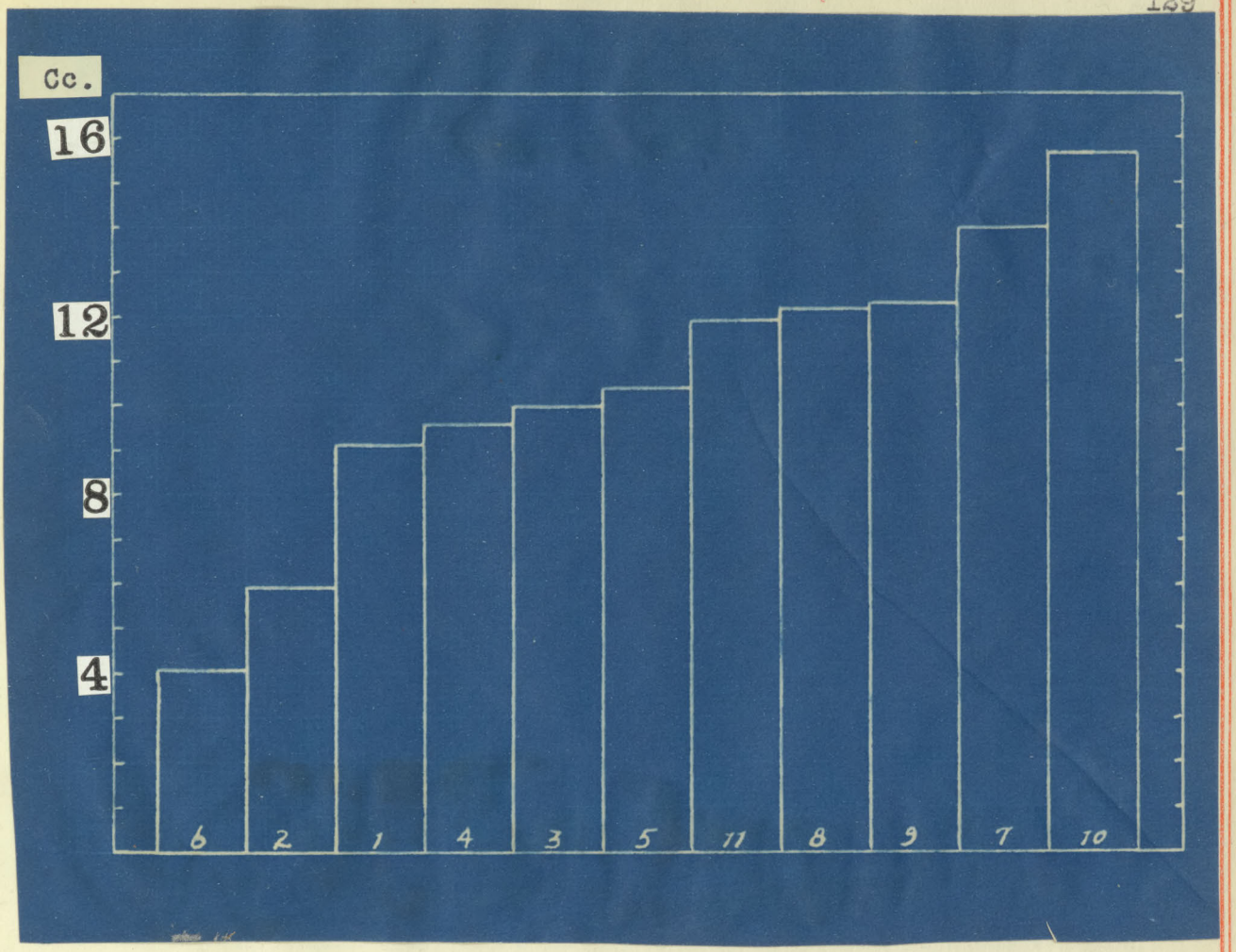


Plate X

Plate XI. Evaporation and Precipitation Data

Mean Daily Evaporation from Porous Cup Atmometer at Station 1, and Total Weekly Precipitation at Urbana.

The upper portion of the diagram represents the mean daily evaporation for each week, beginning with the week ending July 4. Each vertical division of the scale represents 5 cc. per day.

The lower portion of the diagram represents the total weekly precipitation, beginning with the same week. Each vertical division of the scale represents one inch of rainfall.

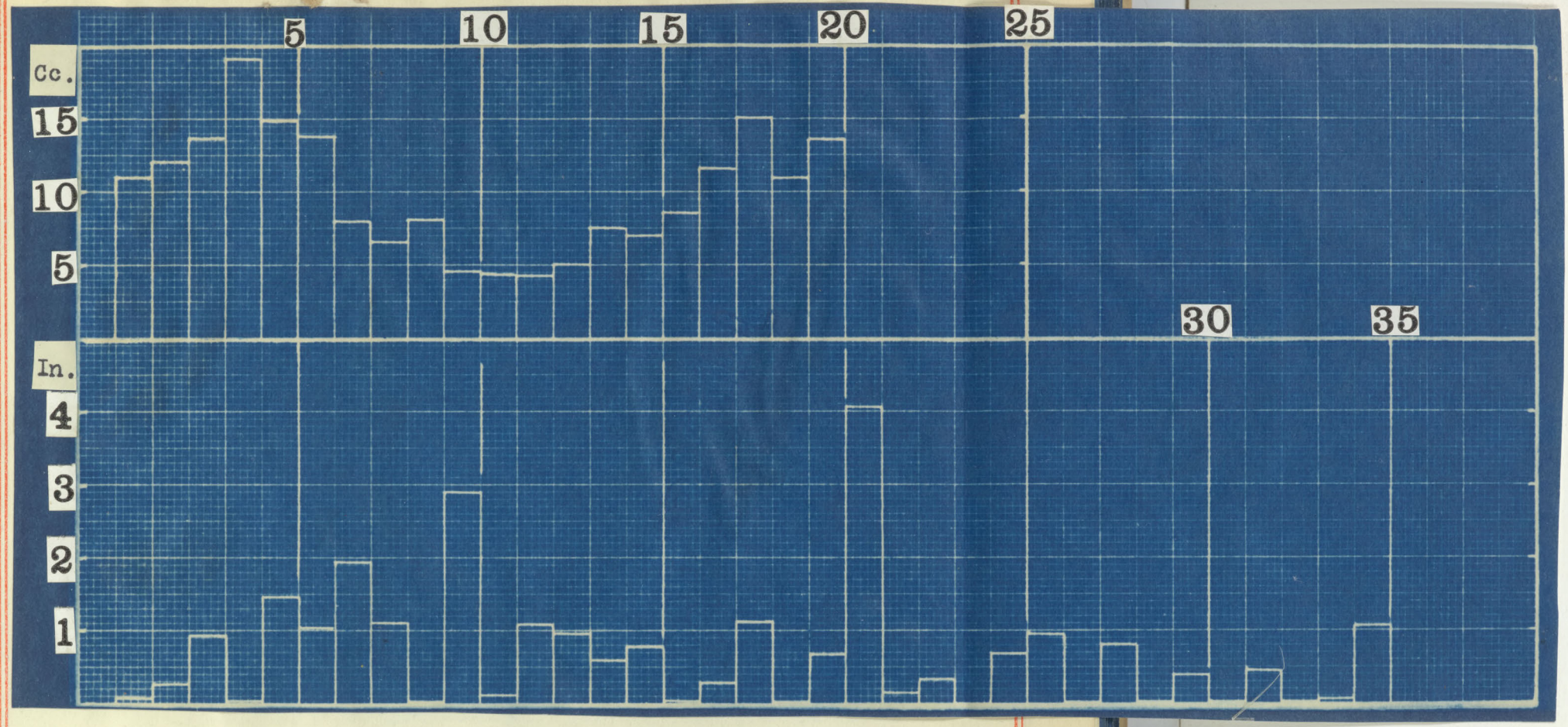


Plate XI

Plate XII. Animal Population Data

The Total Population, and the Population of the Herb and Shrub Strata of the Forest, July 1, 1921 to March 1, 1922. Curves showing the mean weekly temperature at Station A (t) and mean weekly evaporating power of air at the same place (e) are added to this plate for reference. The former is a copy of curve A of Plate I, and the latter is the curve obtained by joining the tops of the rectangles representing evaporation in Plate XI. The curves for humidity(Plate V) rainfall (Plate XI) evaporation (Plates VIII, IX) and temperature variation (Plate II) should also be compared.

a -- Total Population

b -- Population of Herb Stratum

c -- Population of Shrub Stratum

e -- Mean evaporating power of air.

t -- Mean temperature.

The vertical scale represents the number of animals per sample.

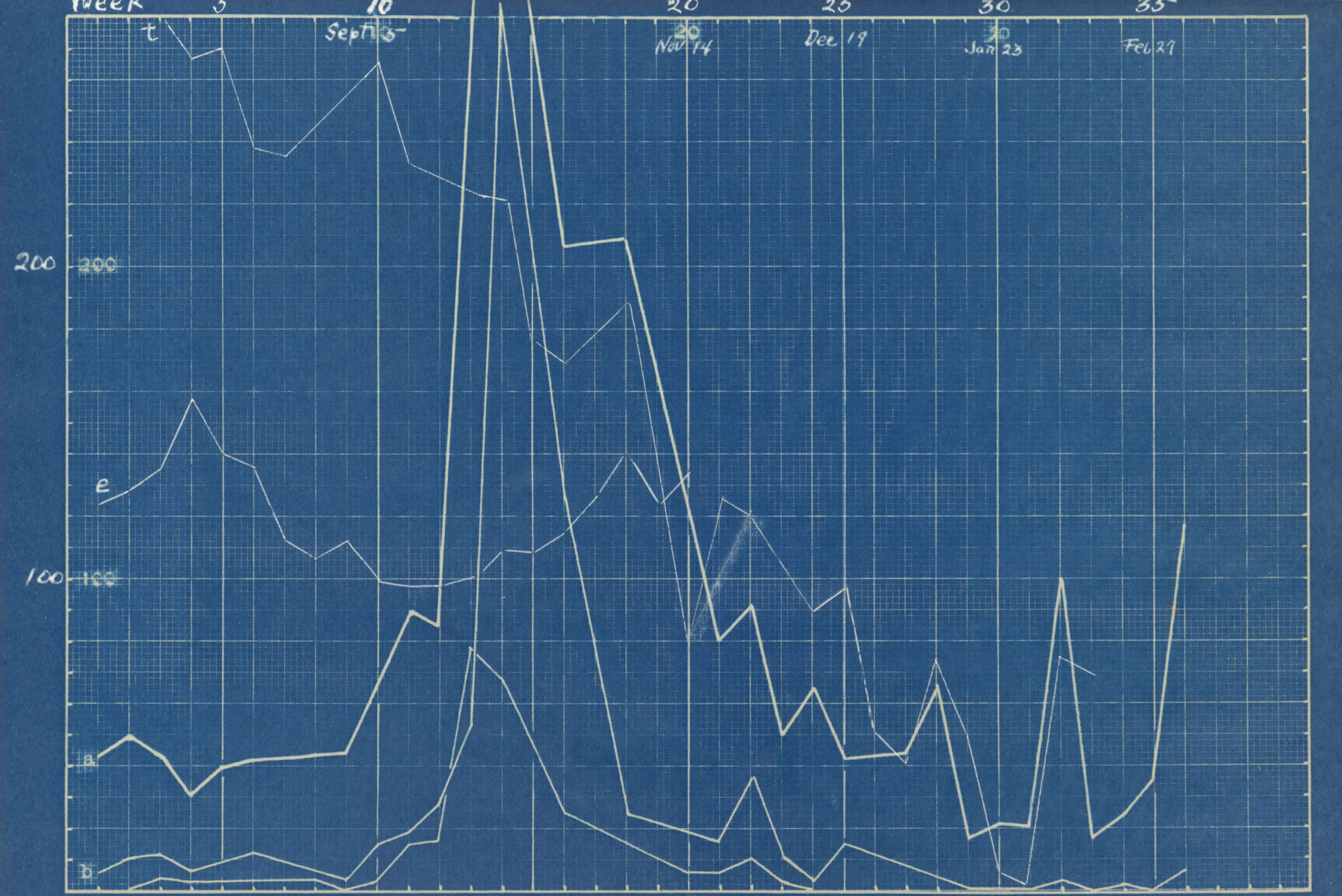

Week
5
10
20
25
30
35
t
Sept 5
Nov 14
Dec 19
Jan 23
Feb 27
200
e
100
a
b

Plate XII

Plate XIII. Animal Population Data

The Population of the Leaf and Soil Strata of the Forest, July 1, 1921, to March 1, 1922.

The vertical lines divide the time into five-week periods, as in Plate XII. Each division in the vertical scale represents ten animals per sample.

d -- Population of the Leaf Stratum

e -- Population of the Soil Stratum

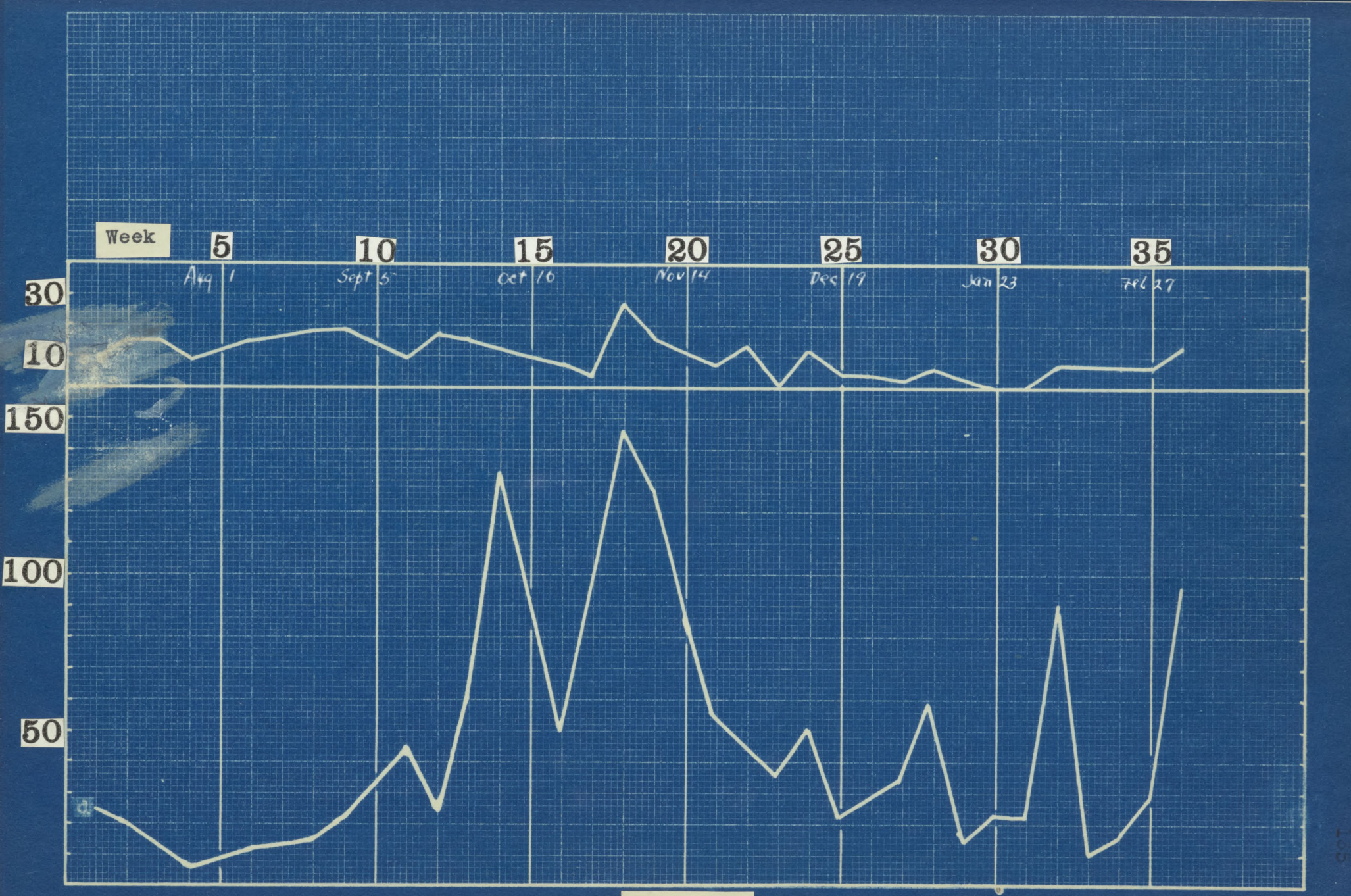

Week
5
10
15
20
25
30
35
Aug 1
Sept 5
Oct 10
Nov 14
Dec 19
Jan 23
Feb 27
30
10
150
100
50

Plate XIII

Plate XIV. Seasonal Occurrence of Molluscs

The vertical lines represent time intervals of five weeks, beginning with June 27.

1 -- Polygyra thyroides (Say)

a -- shrub stratum

b -- herb stratum

c -- leaf stratum

2 -- Circinaria concava (Say)

a -- herb stratum

b -- leaf stratum

3 -- Vitrea indentata (Say)

a -- leaf-ground stratum

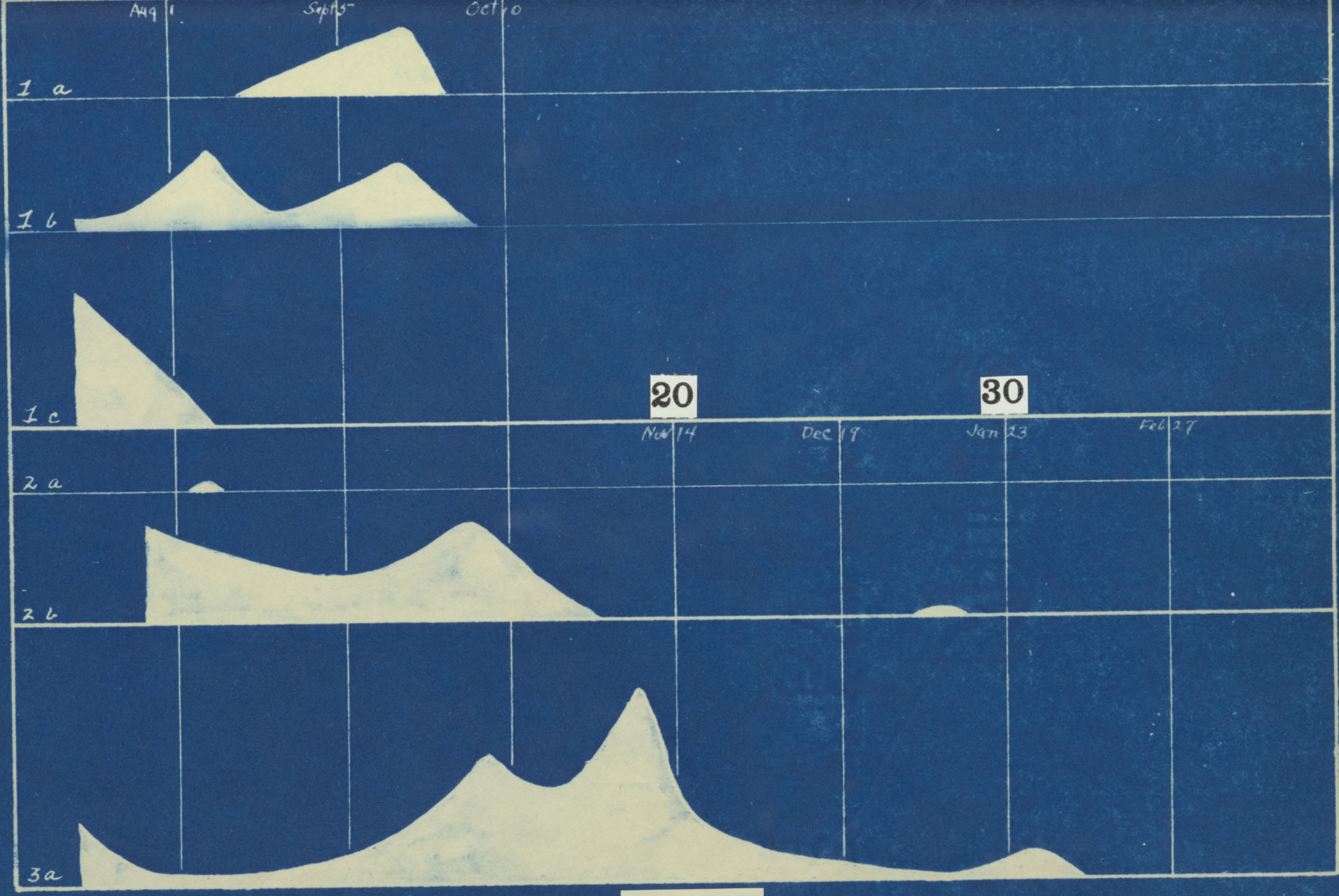

Aug 1
Sept 15
Oct 10
1 a
1 b
1 c
20
30
Nov 14
Dec 19
Jan 23
Feb 27
2 a
2 b
3a

Plate XIV

Plate XV. Seasonal Occurrence of Beetles

1 -- Diabrotica vittata Herbst

a -- shrub stratum

b -- herb stratum

c -- leaf stratum

2 -- Chalepus nervosa Panz

a -- shrub stratum

b -- herb stratum

3 -- Notoxus monodon Fab.

a -- herb stratum

b -- leaf stratum

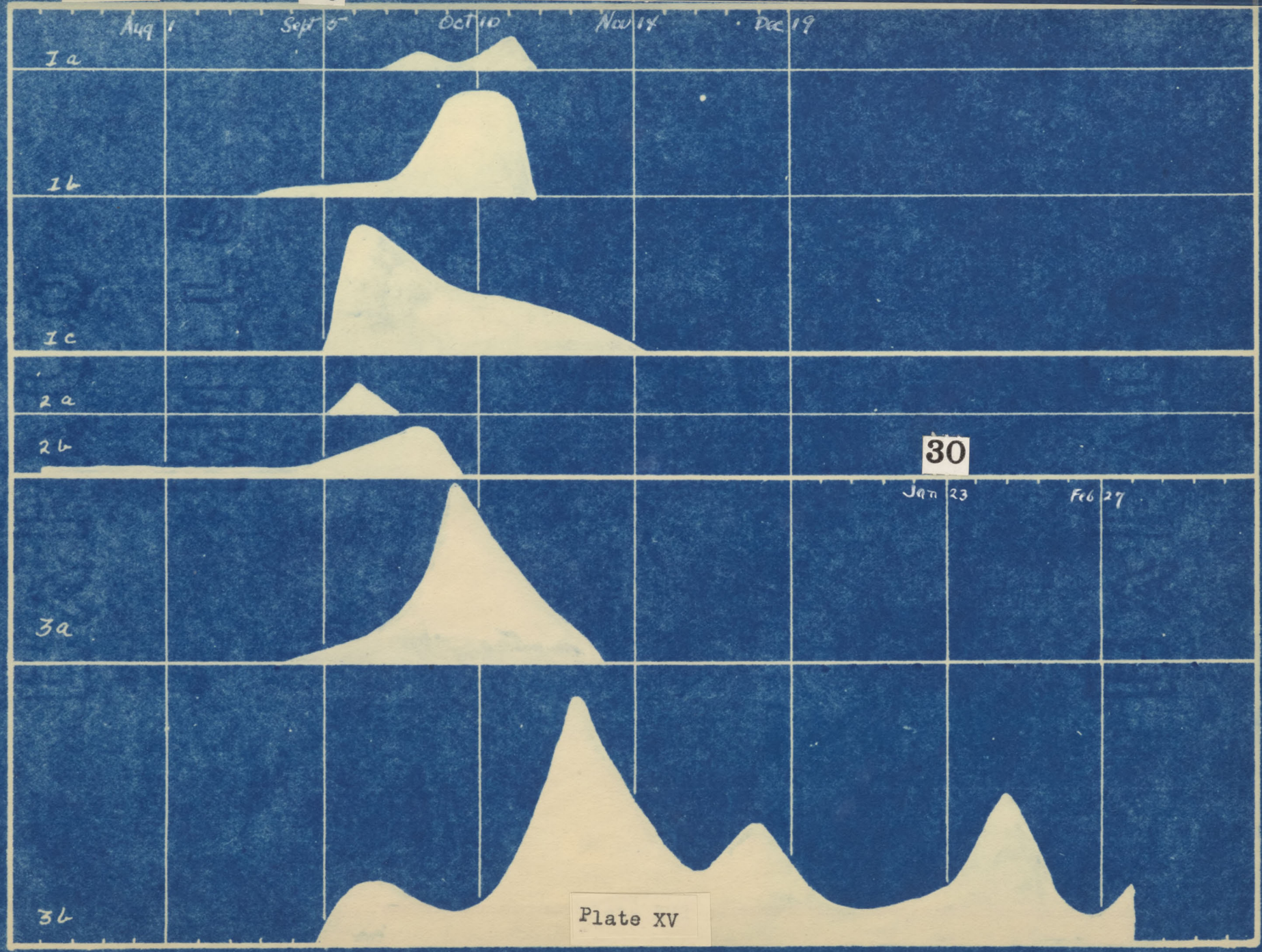

Aug 1
Sept 5
Oct 10
Nov 14
Dec 19
1a
1b
1c
2a
2b
30
Jan 23
Feb 27
3a
3b

Plate XV

Plate XVI Seasonal Occurrence of Beetles

1 -- Phalacrus politus Melsh

a -- shrub stratum

b -- herb stratum

c -- leaf stratum

2 -- Phytonomus nigrirostris Fab.

a -- herb stratum

b -- leaf stratum

3 -- Telephanus velox Hald.

a -- herb stratum

b -- leaf stratum

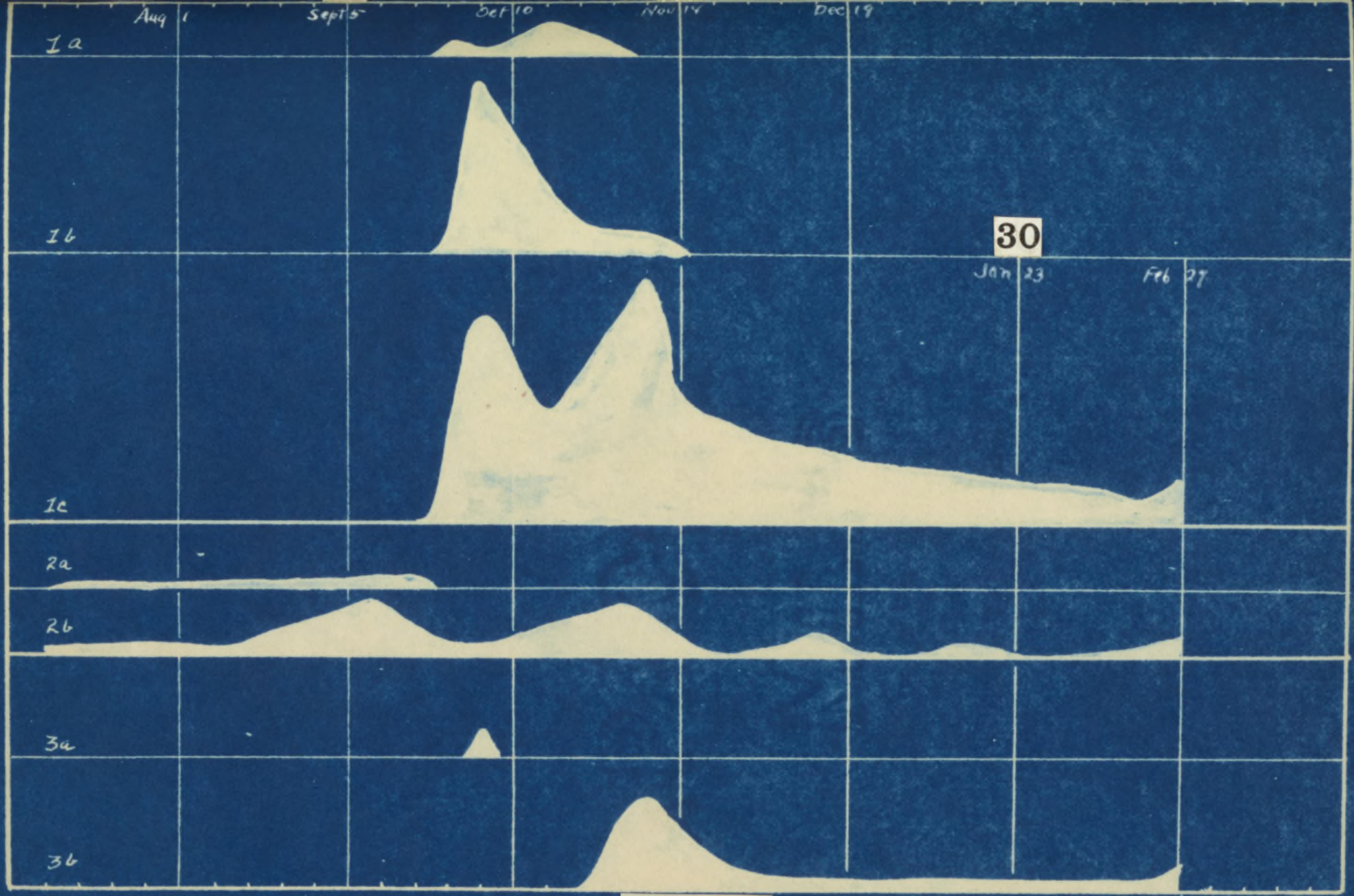

Aug 1
Sept 5
Oct 10
Nov 14
Dec 19
1a
1b
30
Jan 23
Feb 27
1c
2a
2b
3a
3b

Plate XVI

Plate XVII Seasonal Occurrence of Beetles

1 -- Glyptina spuria Lec.

a -- shrub stratum

b -- herb stratum

c -- leaf stratum

2 -- Epitrix brevis Schw.

a -- shrub stratum

b -- herb stratum

c -- leaf stratum

3 -- Epitrix fuscula Crot.

a -- leaf stratum

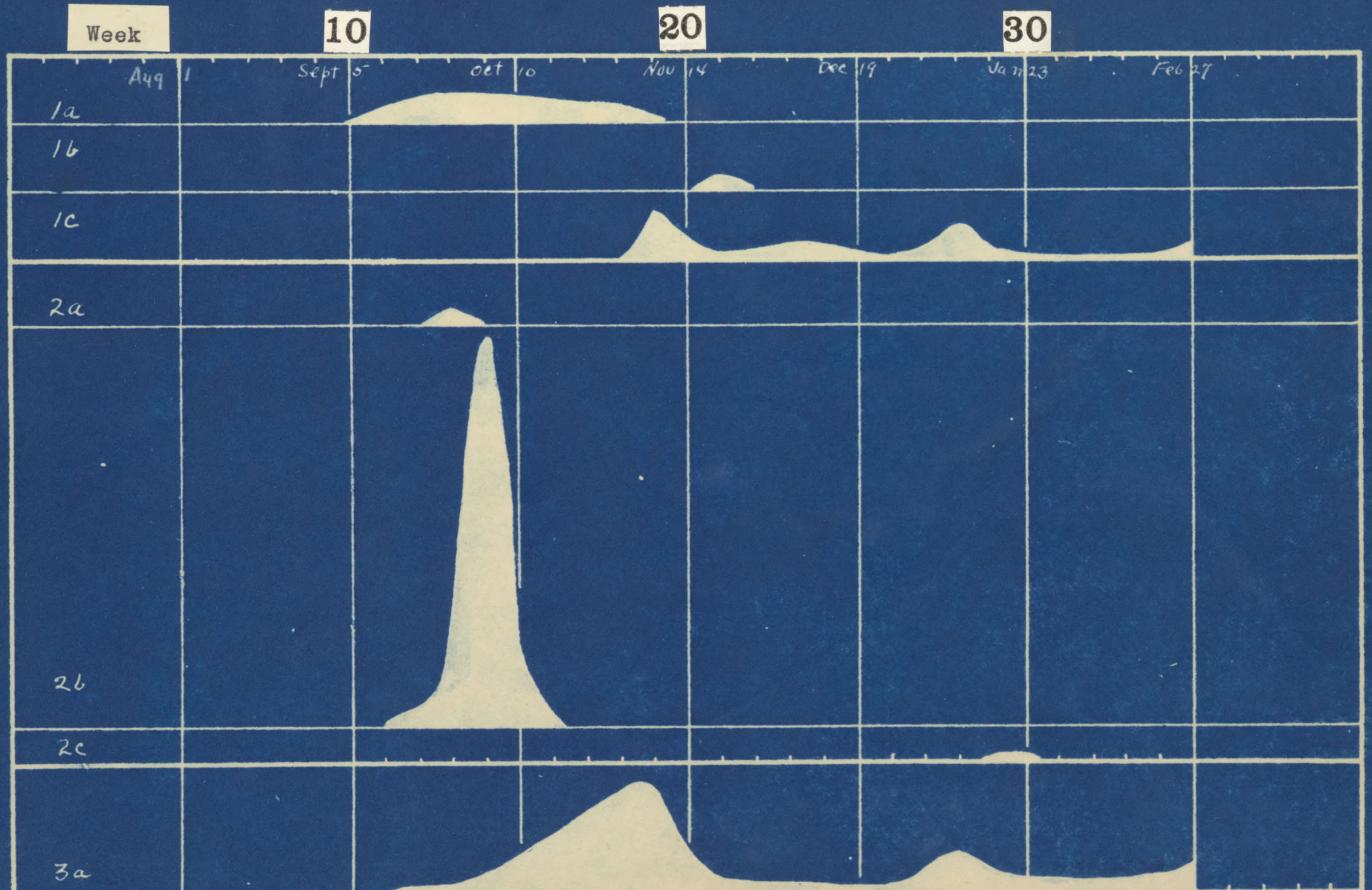

Week
10
20
30
Aug
1
Sept
5
Oct
10
Nov
14
Dec
19
Jan
23
Feb
27
1a
1b
1c
2a
2b
2c
3a

Plate XVIII Seasonal Occurrence of Beetles

1 -- Chaetocnema confinis Crot.

a -- shrub stratum

b -- leaf stratum

2 -- Phyllotreta sinuata Steph.

leaf stratum

3 -- Longitarsus melanurus Melsh.

herb stratum

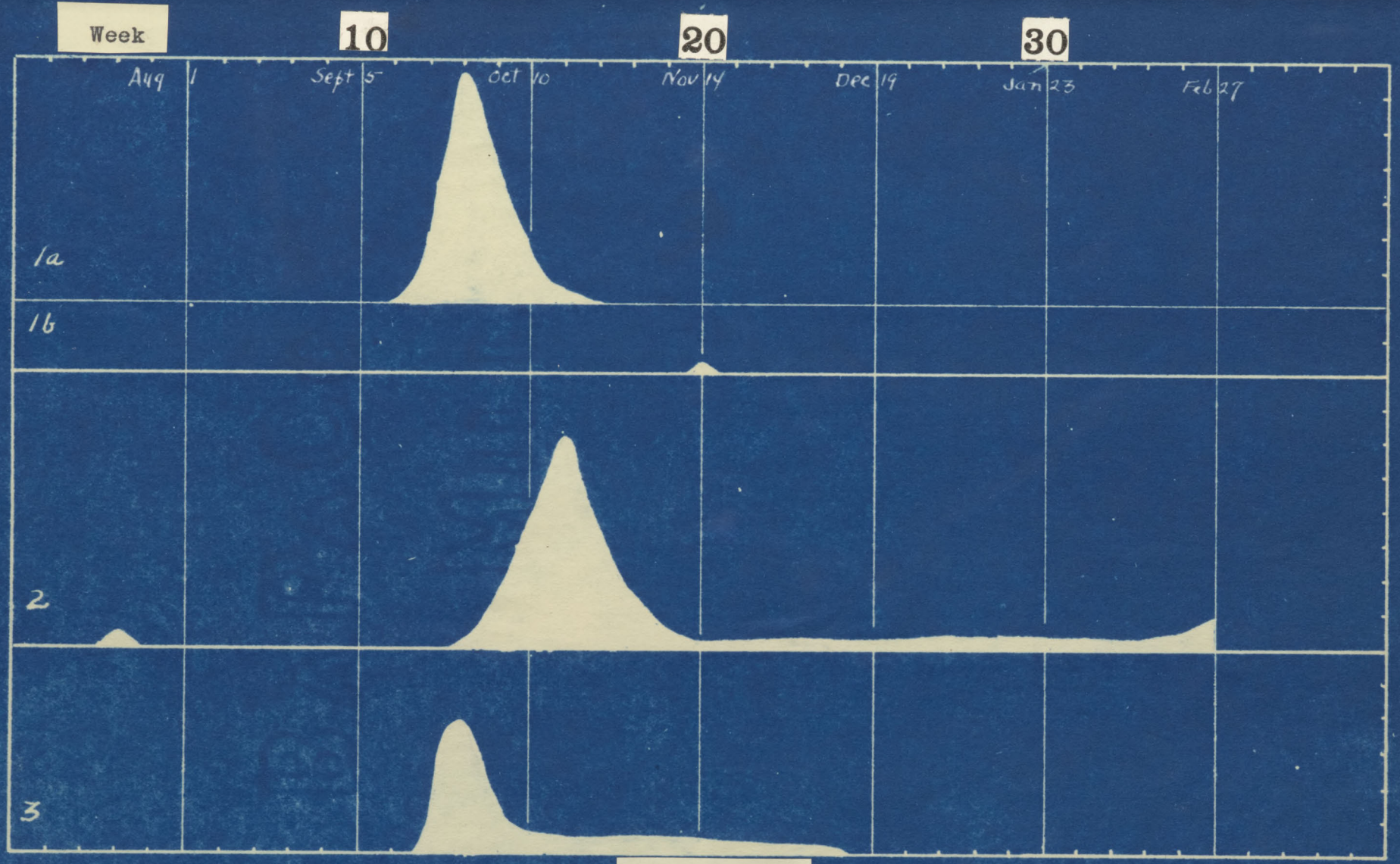

Week
10
20
30
Aug
1
Sept 5
Oct 10
Nov 14
Dec 19
Jan 23
Feb 27
1a
1b
2
3

Plate XVIII

Plate XIX. Seasonal Occurrence of Cicadellidae

t -- total, all species

v -- Empoasca viridescens Walsh

c -- Erythroneura obliqua Say

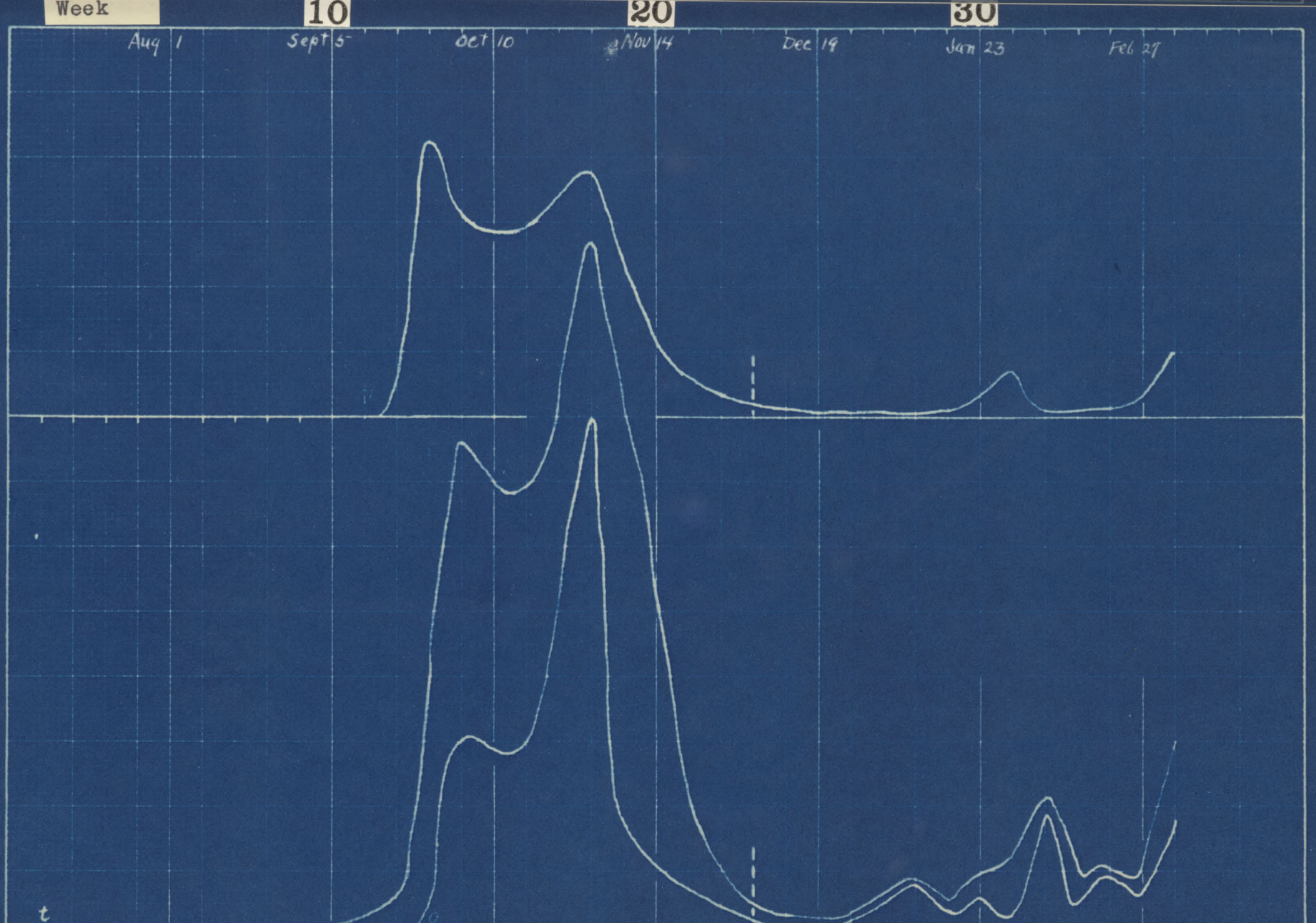

Week
10
20
30
Aug 1
Sept 5
Oct 10
Nov 14
Dec 19
Jan 23
Feb 27
t

Plate XX. Seasonal Occurrence of Spiders

1 -- Dendryphantes aestivalis Emer.

a -- adults

y -- young

2 -- Uloborus americanus Walck

a -- adults

y -- young

3 -- Anyphaena rubra Emer.

The horizontal dotted line represents the point after which all individuals taken were from the leaf stratum

4 -- Dictyna sp?

Horizontal dotted line has same significance as above.

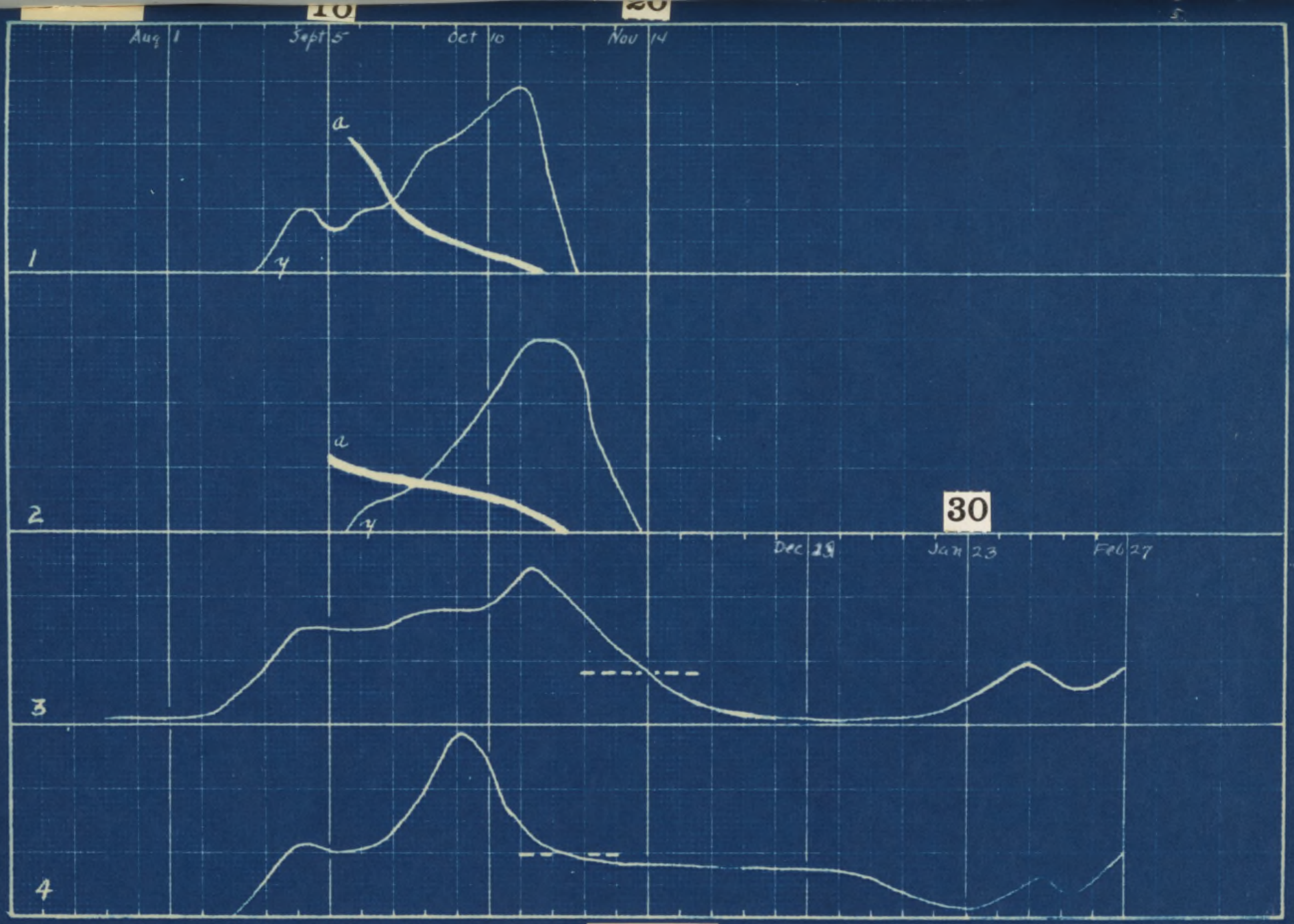


Plate XX

Plate XXI. Seasonal Occurrence of Spiders

1 -- Epeira hortorum Hentz

a -- adults

y -- young

2 -- Epeira gibberosa Hentz

3 -- Tetragnatha sp?

a - adults

y - young

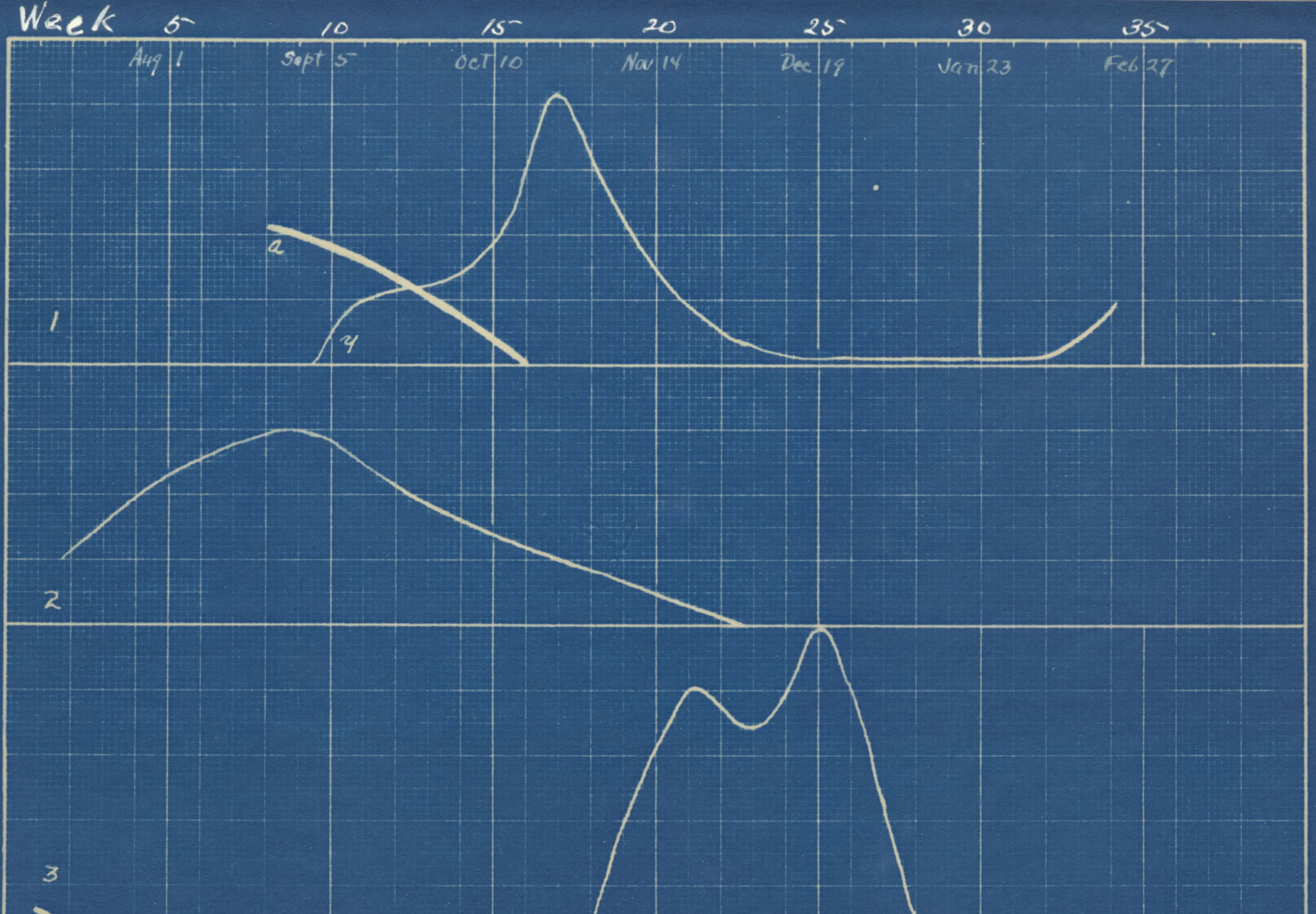

Week
5
10
15
20
25
30
35
Aug 1
Sept 5
Oct 10
Nov 14
Dec 19
Jan 23
Feb 27
a
4
1
2
3

Plate XXII. Seasonal Occurrence of Spiders

1 -- Xysticus elegans Keys

a -- adults

y -- young

Horizontal dotted line as in Plate XX

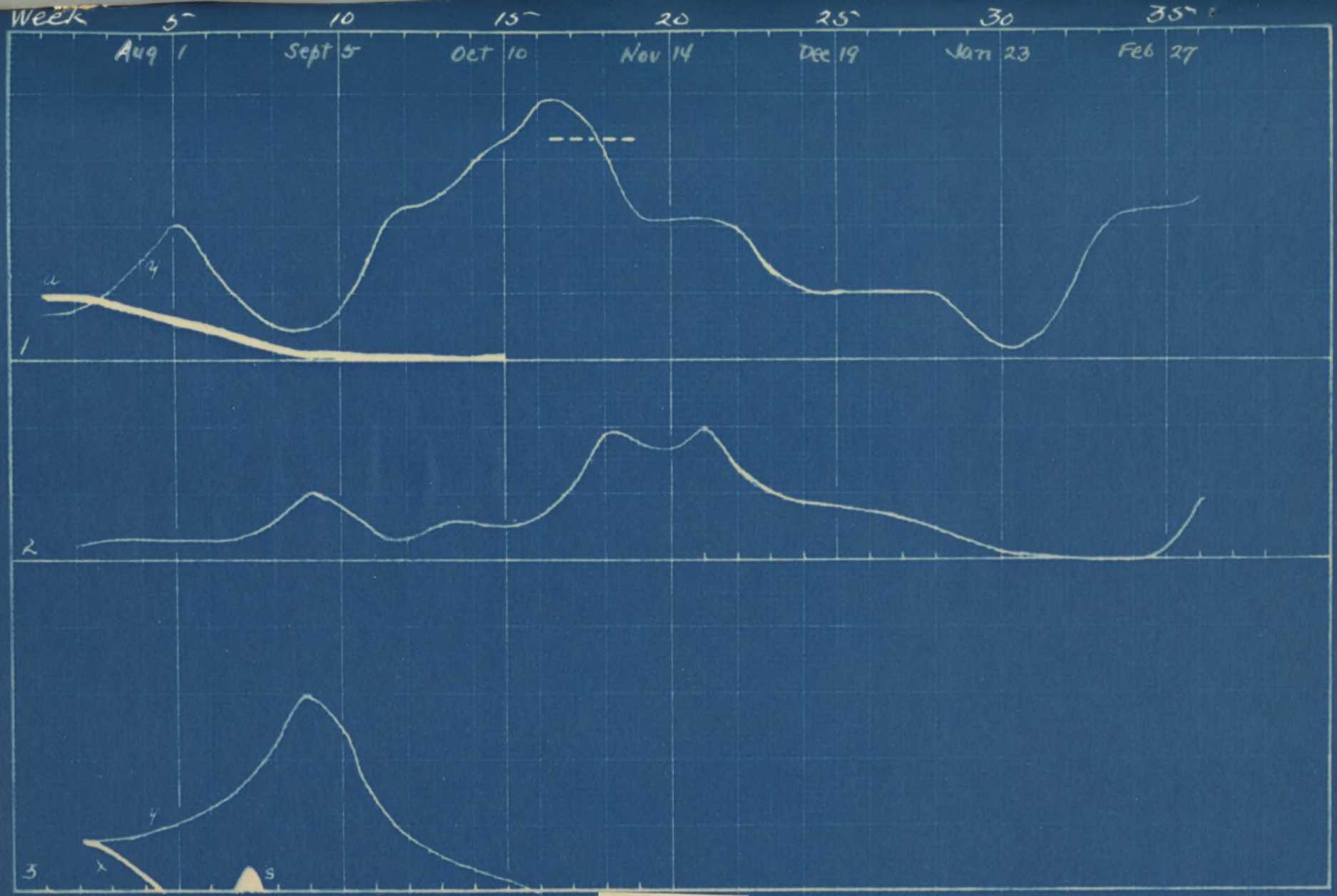
2 -- Linyphia phrygiana Koch

3 -- Acrosoma rugosa Hentz

X -- males

z -- females

s -- Acrosoma spinea Hentz


Week
5
10
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20
25
30
35
Aug 1
Sept 5
Oct 10
Nov 14
Dec 19
Jan 23
Feb 27
a
1
2
3
x
s

Plate XXII

VITA

Asa Orrin Weese was born at Hutchinson, Minnesota, in 1885. He received his preparatory training in the Hutchinson High School from which he graduated in 1902. In 1905 he entered the University of Minnesota, from which he received the degree of B.A. in 1909. The next two years were spent teaching in secondary schools. In the autumn of 1911 he went to the University of New Mexico, at Albuquerque, as Assistant Professor of Biology, and, with the exception of time spent in graduate study elsewhere he has been connected with that institution until the present time. He became Associate Professor in 1914, and Professor in 1915, and during the years 1919-21 he was also Acting Director of the Department of Hygiene. He acted as Dean of the College of Arts and Sciences during the Spring Quarter of 1919. He was elected to membership in Sigma Xi at Minnesota in 1909, and became a member of Phi Kappa Phi at the University of New Mexico in 1916. The American Society of Zoologists elected him to membership in 1916, and he has served as Secretary-Treasurer of the Ecological Society of America since January, 1920. Graduate work was done at the University of California during the summer of 1912, at the University of Chicago during the summer of 1914, and at the Puget Sound Biological Station during the summer of 1920. He matriculated at the University of Illinois at the beginning of the Summer Session of 1916, received the degree of M. A. in 1918, and completed the requirements for the degree of Ph.D. in June, 1922. The following papers on biological subjects have been published:

1. An Experimental Study of the Reactions of the Horned Lizard. Biol. Bull., 32:98-116, 1917.

2. The Urine of the Horned Lizard. Science, N.S., 46:517-518. 1917.

3. Environmental Reactions of Phrynosoma. Am. Nat., 53:33-54, 1919.

4. A Correlation of the Environmental Reactions of Various Animals of the Arid Steppe. Bull. Univ. N.M., Biol.Ser., 3:3:1-20,1919.

5. Some Reactions of the Jellyfish Aequoria. (with M.T.Townsend) Publ. Puget Sound Biol. Sta., 3:117-128. 1921.